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AMERICAN FERN JOURNAL

62-63

1972-1973

MISSOURI BOTANICAL
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AMERICAN FERN JOURNAL

Volume 62

1972

PUBLISHED BY THE AMERICAN FERN SOCIETY

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MP GRAPHICS, BALTIMORE, MARYLAND 21211

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American Fern Journal

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The "American Fern Journal" is an illustrated quarterly devoted to the general study of ferns. It is owned by the American Fern Society, and published at 3200 Falls Cliff Rd., Baltimore, Md. 21211. Second-class postage paid at Baltimore.

Matter for publication and claims for missing numbers should be addressed to the Editor-in-Chief.

Changes of address, applications for membership, subscriptions, orders for back numbers should be addressed to the Treasurer.

Subscriptions $5.50 gross, $5.00 net (agency fee $0.50); sent free to members of the American Fern Society (annual dues, $5.00; sustaining membership, $10.00; life membership, $100.00). Extracted reprints, if ordered in advance, will be furnished to authors at cost, plus postage.

Back volumes $5.00 to $6.25 each; single back numbers of 64 pages or less, $1.25; 65–80 pages, $2.00 each; over 80 pages, $2.50 each; Cumulative Index to Volumes 1–25, 50 cents. Ten percent discount on orders of six volumes or more.

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Collecting Ferns in the Choco, Colombia[1]

DAVID B. LELLINGER* and ELIAS R. DE LA SOTA**

The Departamento del Chocó is the northwesternmost department of Colombia. It is about 475 km long, 25–150 km wide, and encompasses about 47,000 km². It lies adjacent to Panamá and touches the Caribbean Sea on the north and the Pacific Ocean on the west (*Fig. 1*). The Chocó is largely an area of tropical lowlands and swamps, but has a few low mountains along the Pacific coast and some slopes and isolated peaks of the Andes, principally in the southeastern part of the Department. The northern two-thirds, between the Serranía de Baudó and the Andes, is drained by the Río Atrato, the southern third largely by the Río San Juan.

The Chocó is sparsely populated. About 50,000 people live in Quibdó, the capital and only large city. Another 160,000 live in small towns, villages, and settlements, mostly along the rivers and coasts. Despite the low population density (ca. 4.5 people per km²), primitive agricultural and lumbering practices, overgrazing, deforestation, and exploitative mining and timbering have destroyed vast areas of natural vegetation. We had a difficult time finding primary or even undisturbed secondary forest in most areas, even though we walked up to 15 km from rivers and roads in an attempt to find the least disturbed collecting areas.

Of the botanists whom we know to have visited the Chocó, the first and most famous is Celestino Mutis (1732–1808), a Spaniard whose name is commemorated by Puerto Mutis, a settlement at the head of Bahía Solano. We have also seen specimens from the Chocó collected by E. P. Killip and J. Cuatrecasas, by J. Araque Molina and F. A. Barkley, by J. Cuatrecasas, by M. A. Arcos, by H. P. Fuchs, and by W. A. Archer. W. Andrew Archer visited the Chocó about 35 years ago; his published observations "Exploration in the Chocó Intendancy of Colombia" (Sci. Monthly **44:** 418–434. 1937) are still relevant today.

The Chocó has a bad reputation among field biologists, and it is largely deserved.[2] Roads are few. The usual means of transportation are motor launch, dugout canoe, and, to some extent, airplane. Except in Quibdó and three or four other towns, medical care is nonexistent. The annual rainfall, particularly in the Quibdó area, nearly sets world records (8,262 mm per year); in the town of Lloró, 24 km southeast of Quibdó, it is said to be about 10,000 mm per year. The high percentage of cloud

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[1] Fieldwork of the Smithsonian Institution–Museo de La Plata Botanical Exploration of the Chocó was made possible by grants from the National Geographic Society and the Smithsonian Research Foundation. We also wish to acknowlege the help of Prof. D. D. Soejarto, of the Department of Biology, University of Antioquia; Brother Daniel, of the Colegio La Salle, Bogotá; Prof. Maria Teresa Murillo, of the Instituto de Ciencias Naturales, Bogotá; Ing. R. Córdoba G., Dr. L. A. Ramirez, and Dr. J. Alvarez, of INDERENA; Sr. Diego Zapata, of Bahía Solano; Sr. Genero Sanclemente and Sr. Reinerio Palacios, of El Valle; Mr. Gustave Meade, of Medellín; Mr. Denis Marquer and Sr. Gustavo Restrepo, of Charles Masson Duplessis Exportaciones Ltda., Medellín; and Mr. Hans Fischborn, of Colombian Gulf Oil Co., Turbo.

[2] Scientists contemplating field work in the Chocó may find the Logistical Report and the Medical Report of the Smithsonian Institution–Museo de La Plata Botanical Exploration of the Chocó useful. Copies are available from the senior author of this paper.

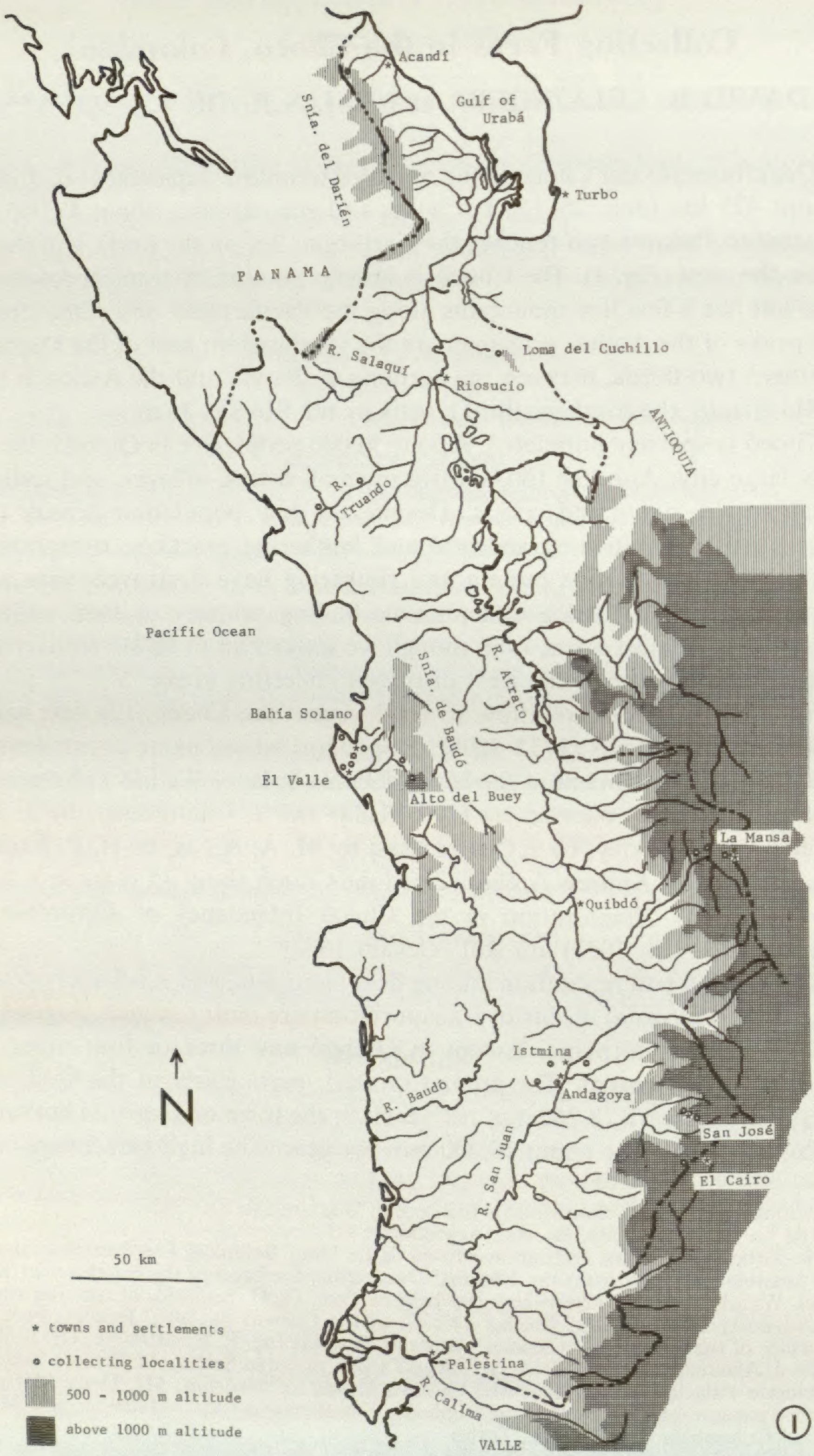

Fig. 1. Map of the Departamento del Chocó, Colombia.

cover keeps temperatures down to tolerable, but still unpleasant, values. We were fortunate because our fieldwork (from January 20 to April 5, 1971) fell during the relatively dry season that usually occurs during the first three months of the year. Although our travels were occasionally slowed by low water in streams, we did not suffer the continual deluges that characterize the Chocó for most of the year.

Because of the few roads leading into the Chocó from the remainder of Colombia, for most of our trips we relied on various twin-engine airplanes to take us to jumping-off points in the Chocó from our base in the large city of Medellín, which is situated about 200 km east from the center of the Chocó in the Aburra Valley in the Cordillera Central. We had excellent working conditions in the herbarium of the University of Antioquia, which has just moved to a new and beautifully designed university city a few minutes from the center of Medellín. The herbarium was begun in 1969 by Prof. D. D. Soejarto, who is building a teaching collection with research specialization in the flora of northwestern Colombia.

At the start of our field work, the Río Atrato was still in flood. Emergency rescue work was being conducted by the government, and so we decided to collect in the Serranía de Baudó area first. We flew to the village of Puerto Mutis (or Bahía Solano, as it is coming to be called). The houses, school, water supply, and portions of nearby roads and bridges were devastated by an earthquake in August, 1970. Eighty percent of the 1,200 residents left after this destruction. The town is slowly rebuilding. Fortunately, we were able to find excellent shelter and capable guides.

To the west and northwest of the village is a steep-sided peninsula with a rather dry lowland forest that we reached by motor launch. We found *Ctenitis protensa* var. *funesta*, *Lindsaea arcuata*, *Lygodium radiatum*, *Metaxya rostrata*, and *Schizaea elegans* to be characteristic of this forest type, both here and along the coast at El Valle. We also collected a tree of the family Lecythidaceae which had violet flowers about 15 cm in diameter growing from its trunk.

From Bahía Solano we explored a trail over the ridges southeast to Miniquía. The secondary forest on the muddy ridges had a much richer fern flora than the bayside hills. Among the ferns we collected were *Danaea moritziana*, *D. nodosa*, *D. wendlandii*, *Tectaria rheosora*, and *Trichomanes pinnatum*, all of which are characteristic of this part of the Chocó. We also collected in wet ravines along the road between Bahía Solano and El Valle.

After making arrangements for our next trip, we flew to Medellín with specimens and returned to Bahía Solano with food and collecting supplies. Our goal was the top of Alto del Buey, at 1810 m the highest point in the Serranía de Baudó. Because the earthquake had destroyed several log bridges, a truck could take us only to Km. 8. We walked four kilometers and, luckily, found the only car in the village of El Valle at the other end of the gap. The best accomodations in town were offered to us by the police; they happened to have extra space in their bunk room. The next day the guide and four bearers we had hired poled us eastward up the Río El Valle in two dugout canoes to a thatched-roof hut that the government had built as a school for the Baudó Indians of the area. We enjoyed talking with the Indians, learning about their crops, foods, and medicines, and seeing the various things they made for their houses and plantations. Once they found out that we were botanists, they

Fig. 2. The camp on Alto del Buey, ca. 1250 m altitude. Fig. 3. San José del Palmar, with the forested ridge to the east, ca. 1600 m altitude.

asked many questions about improving their crops. We hired one of the Indian men to help guide us up Alto del Buey. After an hour's travel the next morning, we turned southeastward into the much smaller Río Mutatá. Soon the canoes had to be beached, and we walked for several hours along and through the rocky stream to a high sandbar not far from the ridge leading to Alto del Buey. The men constructed a shelter roofed with palm fronds and made tight with plastic sheets we carried, where we stayed two days.

The flood-plain forest was undisturbed, other than by occasional flooding, and bore a rich fern flora. We found many of the same species that grew near Bahía Solano, but also *Diplazium brasiliense*, *D. seemannii*, a new species of *Diplazium* sect. *Anisogonium*, *Elaphoglossum proliferans* (the second record for Colombia), several new species of *Elaphoglossum* and *Trichomanes gourlianum*, an unusually large, pinnate-pinnatifid species of subg. *Didymoglossum*.

The following morning, while some of the men cleared a trail up Alto del Buey and began to build a shelter half way up for succeeding days, we explored the steep hillside behind the camp and flood plain. The abundant and varied aroids and the salmon-colored begonias more than two feet tall were more spectacular than the ferns, although we did collect several species of ferns that we had not seen on the flood plain, including *Bolbitis nicotianifolia* and *Trichomanes ankersii*, which has a thin rhizome that creeps up smooth tree trunks and somewhat bipinnatifid fronds that are adherent to the trunk.

The next day we waded up the Río Mutatá to the base of the ridge leading to Alto del Buey. Allowing the guides carrying supplies to precede us, we walked up slowly, collecting as we went. The flora was much the same as on the hillside behind the flood plain. By early afternoon we reached the shelter, which was nearly complete. We helped to set up camp, and then pressed and took notes on the day's collection (*Fig. 2*). The weather remained good, with only occasional drizzles, and so we hoped for a pleasant climb through the mossy forest to the top on the following day.

We were not disappointed, either in the weather or the ferns. The mossy forest proved to be the richest of any we found in the Chocó. Especially notable were the abundant Polybotryas, including *P. cervina*, *P. lechleriana*, *P. osmundacea*, and a new species. We found eight species of *Elaphoglossum*, including three new ones. Two Andean elements otherwise rare in the Chocó, *Blechnum* and *Lophosoria*, were also present. The number of Aspleniaceae (1) and Grammitidaceae (6) were fewer than we expected, which we attributed to the short but noticeable dry season. At the top, which has been cleared and an aluminum reflector placed for cartographic triangulation, we found magnificent views south along the Serranía. The forest appeared unbroken on ridge after ridge, much like that of the national forests in the southern Applachian mountains.

Our third trip was to the upper Río San Juan region. We made our headquarters in the old town of Istmina, where there is a comfortable tourist hotel at the edge of the river. We engaged guides with a dugout canoe to take us to the Mojarras de Tadó, a group of sugar-loaf mountains 8.5 km to the east of Istmina. Most of the area had been logged or cropped at one time or another, but near the base of the

mountains were ravines with *Adiantum kalbreyeri*, *Saccoloma inaequale*, and a new species of *Thelypteris* sect. *Steiropteris*. The talus slope was interesting, too. We found *Thelypteris turrialbae*, a new record for Colombia. We were glad that the guides led the way, for we had an encounter with poisonous snakes; the guide killed two small Bothrops in close succession as we were making our way down an old logging trail. The local people, most of whom walk barefoot, have developed the necessary ability to spot such hazards. They rarely leave their houses without carrying a machete for defending themselves.

One hot and sunny day we walked along the road that runs west from Istmina to Pie de Pepé, which is the head of navigation for the Río Pepé and which was a principal entrance to the area prior to the time of airplanes. Collecting was poor. We returned tired and discouraged, but among the collections were *Lycopodium trianae* and *Thelypteris polyphlebia*, both fairly rare species.

In order to see how uniform the fern flora was in this area, we took a motor launch down the Río San Juan to Andagoya, where we hired two boys with a dugout canoe to pole us down the Río San Juan and westward up the Río Suruco and Río El Salto to a gold and platinum mine run by Mr. Gustave Meade, a transplanted and thriving Texan. The fern flora in the ravines and on the low hills was much the same as we had found at Istmina. We collected *Tectaria acutiloba*, *Trichomanes diversifrons*, and *T. osmundoides*, all characteristic of the fern flora of the upper Río San Juan. We also found some new species of *Elaphoglossum*, one of *Thelypteris* sect. *Steiropteris*, and *Tectaria draconoptera*.

Because we have access to J. Cuatrecasas' collections from the lower Río San Juan and vicinity and to H. P. Fuchs' collections from the Río Baudó, we decided to devote the remainder of the time we could spend in the lowland Chocó to the northern portion. We flew to Turbo, in northern Antioquia at the edge of the Gulf of Urabá. Thanks to the INDERENA staff stationed there, we were able to use their motor boat and driver to go across and through the waves on the gulf (we got thoroughly soaked) and up the Río Atrato to the inundated town of Riosucio. It is possible to fly there only during the dry season, after the Río Atrato recedes. We likened the town to a tropical Venice, because the streets were shallow canals, but with plank bridges from the very narrow plank sidewalk in the middle of the street to each house or store. The next day we went by motorized dugout canoe up the Río Truando to the INDERENA camp at La Teresita, which is close to secondary forest in good condition. The climate here is somewhat drier than at Istmina, and this is reflected in the ferns that we found. *Adiantum petiolatum*, *A. pulverulentum*, *A. tetraphyllum*, *Diplazium cristatum*, *D. delitescens*, and several species of *Campyloneurum* are characteristic.

We also visited the MADUREX lumber camp farther up the Río Truando, which is located in forest less disturbed than that at La Teresita, and which was richer in epiphytes, including *Elaphoglossum apodum*, *E. curvans*, *E. herminieri*, *E. palmense*, *E. rigidum*, *E. tovarense*, and two new species of that genus, plus *Trichomanes curtii* and *T. sublabiatum*. Part of the trip to and from the lumber camp was made in a Timber-Trac, an immensely powerful and noisy diesel tractor with tires six feet high. It went through streams and mud five or six feet deep, carrying us and our

gear and pulling a gasoline tank on wheels behind. It ground along at about one mile an hour, which added up to the slowest and two most uncomfortable hours we spent in the Chocó.

The only totally unsucessful trip we took was from Riosucio to the upper Río Salaquí. The entire area was once a dry forest, but it had been reduced to crop and grazing lands, with only the unusable Bombacaceae left standing. These enormous trees, some 150 feet tall, have swollen lower trunks, as if they contained more water pressure than they could bear. This area clearly had a monsoon climate, and at the time we visited (early March) was quite dry. We were able to make arrangements to use a small helicopter for reconnoitering Loma del Cuchillo, thanks to the Colombian Gulf Oil Company, which had established a survey camp on the upper Río Salaquí.

It is easier to fly over Loma del Cuchillo than to go there by boat or on foot. Because of the low water in the Río Atrato and its tributaries, the motorized dugout canoe and guides we hired in Riosucio were unable to reach the Loma by boat. Instead, we had to beach the boat and walk for half a day, through weedy, once-cultivated fields and through the forest on low ridges near the west end of the Loma. We made a base camp at a comfortable, thatched-roof farm house that belonged to the uncle of one of the guides.

The next day we climbed the mountain, which is over 500 m high. It was a surprisingly steep and difficult climb, considering its small size. Having a slight case of amoebic dysentery did not add to our comfort or efficiency. We did find *Adiantum wilsonii* and *Bolbitis donnell-smithii*, neither of which is common in the Chocó. Because the Loma is an outlier of the Andes, we thought that it might bear a more or less Andean fern flora, but such is not the case; the ferns we found were by and large typically Chocó species.

The northernmost part of the Chocó is a strip of land lying between the Gulf of Urabá and the ridge of the Serranía del Darién. It is most easily accessible from Acandí, where an old, abandoned railroad bed runs west to the foothills of the Serranía. We penetrated to the base of the main ridge and collected there many species typical of the Costa Rica and Panamá fern flora, including *Adiantum macrophyllum*, *Campyloneurum serpentinum*, *Lastreopsis effusa* var. *guatemalensis*, and *Tectaria euryloba*.

In order to decide upon the altitudinal extent of the Chocó fern flora, we spent the last two weeks of field work in the southeastern part of the Chocó, where the boundary of the Chocó runs along the summit of the westernmost range of the Andes.

To reach the first study area, we flew to Pereira to hire a jeep and driver, who drove us west across the flooded valley of the Río Cauca and up into the Cordillera Occidental. About ten miles from the nearest mountain town, the jeep broke a spring shackle, halting the car. The driver hitched a ride towards the town and returned and installed the part practically without tools, all within an hour and a half!

We stayed briefly at San José del Palmar (*Fig. 3*). Although disturbance limited the number of ferns visible from the road nearby, we made a transect from below 500 m altitude to about 1500 m. According to our observations, the boundary between the Chocó and the Andean fern floras lies at to a little above 1000 m altitude.

Behind the cemetery at San José del Palmar (1100 m) we found a very disturbed secondary forest that contained both Chocó elements like *Diplazium brasiliense* and *Campyloneurum latum* and also Andean elements like *Grammitis lanigera* and *Selaginella poeppigiana*. On the ridge to the east of the village (upper portion of *Fig. 3*), which was at 1550–1650 m, Andean species were more prevalent, including *Asplenium hastatum*, *Blechnum tomentosum*, *Microstaphyla colombiana*, *Pteris speciosa*, and *Thelypteris praetervisa*.

We also drove farther south along the Cordillera Occidental to the town of El Cairo. From there we went on mule and horseback southward to the Serranía de Los Paraguas, an aptly named range, although more than umbrellas would have been necessary to ward off the almost continuous downpours. The trail was rough and muddy, often with deep pockets made by the animals' treading in one another's footsteps. We were very fortunate to find a small farmer's cottage with an ample front porch that we could sleep, eat, and prepare specimens on.

Although the forest was disturbed, secondary, and in some places served as a shelter for cattle when the pastures became too unbearably cold and wet, we found that the disturbance increased the diversity of ferns, probably by opening up a wide variety of microhabitats. At this point the dividing ridge between the Chocó and the Departamento del Valle lies at 2200–2250 m. We collected *Campyloneurum fendleri*, *Elaphoglossum huacsaro*, *Eriosorus hirtus*, *Gleichenia rubiginosa*, two Ecuadorian species of *Grammitis*, *Selaginella schmidtchenii*, and *Thelypteris longicaulis*.

In order to confirm our observations from San José del Palmar and the Serranía de Los Paraguas, we made another trip from Medellín. Again we hired a jeep and driver to drive to a second point in the Cordillera Occidental, where we stayed in the town of Ciudad Bolívar, which is on the road from Medellín to Quibdó.

We collected at several altitudes along the road, which is the only one that penetrates more than a few miles into the Chocó. Because it is an old road, and before that a mule trail, it is almost completely bordered by pastures and farm lands. But we found patches of secondary forest at 750 m altitude that had a fairly typical Chocó fern flora, including one new species of *Cnemidaria* and one of *Thelypteris* sect. *Glaphyropteris*.

A brief stop in a highly disturbed and weedy forest at 1500 m altitude yielded Andean ferns: *Blechnum cordatum*, *Dennstaedtia bipinnata*, and *Polystichum platyphyllum*.

On the following day, we collected at the dividing ridge of the Chocó and the Departamento de Antioquia, west of the town of La Mansa. Here we found a typically Andean fern flora in secondary forest at an altitude of 2100–2200 m: *Asplenium serra*, *Blechnum stipitellatum*, four species of *Elaphoglossum*, five of *Hymenophyllum*, *Hypolepis nigrescens*, *H. parallelogramma*, *Polypodium adnatum*, and *Trichomanes lucens*. The many interesting specimens, the bracing mountain air, and the marvellous views of the mountains made a welcome conclusion to our generally hot and wet exploration of the Chocó.

Fern Sources in the United States–1972

DONALD G. HUTTLESTON*

The article on "Fern Sources in the United States" (Amer. Fern J. **52**: 97–109. 1962) proved popular, and I have had requests to revise it. As before, I attempted to find all nurseries offering more than 3 or 4 common species. I want to thank the members of the Society who advised me of nurseries.

In the 1962 article, 69 nurseries were listed, whereas only 46 are listed here. I wrote to all the nurseries listed earlier plus a number of additional ones. Some of these requests for available ferns prompted no replies, and a few responded by saying that they no longer carried ferns.

There are several things that should be borne in mind by persons using this article. Inasmuch as it was impossible for me to check the identifications of ferns offered, I have had to assume that the nurseries are correct. In many cases, different nurseries carry the same fern under different names. In those cases where I was fairly certain of this, I listed them under one name even though it may cause some confusion in ordering. However, I expect to apprise the nurseries of this in the hope of solving the problem. For northeastern ferns, I have followed the nomenclature found in Dr. Wherry's "The Fern Guide."

A few cash-and-carry nurseries (indicated by C & C) are included if they handle a number of unusual species. All nurseries listed are retail, mail order firms unless otherwise indicated (W = wholesale only; W & R = wholesale and retail) and sell plants only, except those marked with S (spores only) or S & P (spores and plants). The three or four letters preceding the name of each nursery constitute the code designation of that nursery. For nurseries included in the sixth edition of the "Plant Buyer's Guide," the code designations are the same. The groups of three or four letters following the name of a fern are the code designations of nurseries listing that fern. Cultivated varieties not referred to a particular species are listed last within each genus.

NURSERIES LISTING FERNS

AlFh Fern Hill Farm
Rt. 3, Box 191
Greenville, Ala. 36037

CaCj California Jungle Gardens
11977 San Vincente Blvd.
Los Angeles, Calif. 90049

CaEm El Modeno Gardens W
19140 East Chapman
P. O. Box 2212
El Modeno, Calif. 92669

CaFl Mike Kashkin C & C
Fuchsia Land
4629 Centinela Avenue
Los Angeles, Calif. 90066

CaGh Flora Greenhouses
Box 1191
Burlingame, Calif. 94010
Minimum order $5

CaR Clyde Robin
P. O. Box 2091
Castro Valley, Calif. 94546
Minimum order $1; Catalogue 50¢

* Longwood Gardens, Kennett Square, PA 19348.

CaSs Carl Stephens
The Shop in the Sierra
Box 1
Midpines, Calif. 95345

CaTa Talnadge's Fern Gardens
354 G Street
Chula Vista, Calif. 92010
Minimum order $5; Catalogue 25¢

CaWo Wilson Orchids
490 Beverly Avenue
San Leandro, Calif. 94577

CnLo Logee's Greenhouses
55 North Street
Danielson, Conn. 06239
Minimum order $6, Catalogue 50¢

CnRh Ruth Hardy's Wildflower Nursery
Falls Village, Conn. 06031
Catalogue 50¢

CnWf White Flower Farm
Litchfield, Conn. 06759
Minimum order $5; Catalogue $2

FlA Albert & Merkel Bros., Inc.
Boynton Beach, Fla. 33435

FlFa Fantastic Gardens C & C
9550 S. W. 67th Avenue
Miami, Fla. 33156

IlLg Lounsberry Gardens
P. O. Box 135
Oakford, Illinois 62673

InHe Hendersons Botanical Gardens
Route 6
Greensburg, Indiana 47240

KaTp Tropical Paradise Greenhouse
8825 W. 79th Street
Overland Park, Kansas 66204
Minimum order $10

MaAa Arthur Eames Allgrove
North Wilmington, Mass. 01887

MaBg Blackthorne Gardens
48 Quincy Street
Holbrook, Mass. 02343
Catalogue $1

MaLe Leslies' Wild Flower Nursery S&P
30 Summer Street
Methuen, Mass. 01844
Catalogue 25¢

MdBm Bluemount Nurseries, Inc. W
Box 219, Rt. 2, Blue Mount Road
Monkton, Maryland 21111

MeMg Merry Gardens
Camden, Maine 04843

MeRg The Rock Garden
R. F. D. #2
Litchfield, Maine 04350
Minimum order $3.50

MiRk Rakestraw's Gardens
G-3094 South Term
Flint, Michigan 48507
Catalogue 25¢

MnFe Ferndale Nursery & Greenhouses
Askov, Minnesota 55704

MnOg Orchid Gardens
Route 1, Box 290
Grand Rapids, Minnesota 55744
Catalogue 25¢

NcBr Gardens of the Blue Ridge
Ashford, McDowell County
North Carolina 28603

NcTl The Three Laurels
Marshall, Madison County
North Carolina 28753

NhFs Francis M. Sinclair W & R
R.F.D. 1, Newmarket Road
Exeter, New Hampshire 03833

NhSk Stella J. Skiba S & P
Bluff Road, Salem Depot
New Hampshire 03079

NjEg Edelweiss Gardens
54 Robbinsville-Allentown Rd.
Robbinsville, New Jersey 08691
Minimum order $5.75, Catalogue 35¢

NjMi Mincemoyer Nursery
County Line Road, Route 526
Jackson, New Jersey 08527
Minimum order $5

NjR Julius Roehrs Company W & R
P. O. Box 125
East Rutherford, New Jersey 07073

OhSh Spring Hill Nurseries W & R
Tipp City, Ohio 45371

OhWm Wayside Gardens
Mentor, Ohio 44060
Catalogue $2

OrKf Kramers C & C
4543 SE Harney Drive
Portland, Oregon 97206

PaLl Lakeland Nurseries Sales
Hanover, Penna. 17331

PaVw Vick's Wildgardens
Box 115
Gladwyn, Penn. 19035
Minimum order $5

ScGp George W. Parks Seed Co S
Greenwood
South Carolina 29646

TeBe Beersheba's Wildflower Gardens
Beersheba Springs W & R
Tennessee 37305

TxNh Northhaven Gardens, Inc. W & R
7700 Northhaven Road
Dallas, Texas, 75230

WaJv Jamieson Valley Gardens
Route 3, Box 648
Spokane, Washington 99203
Catalogue 50¢

WaLc Laura's Collectors' Garden
5136 South Raymond Street
Seattle, Washington 98118
Minimum order $10

WaLn Lamb Nurseries
East 101 Sharp Avenue
Spokane, Washington 99202

WaWi The Wild Garden
8243 N. E. 119th
Kirkland, Washington 98033
Catalogue $1

WiWa Woodland Acres Nursery
R. D. 2
Crivitz, Wisconsin 54114

KEY TO SUPPLIERS, BY SPECIES AND CULTIVARS

ADIANTUM
banksianum CaTa
bellum CnLo, FlA
capillus-veneris AlFh, CnLo, TxNh
——'Fimbriatum' CaTa
——'Incisum Footii' CaTa
caudatum CaFl, CaTa, KaTp, NjEg, NjR
curvatum KaTp
hispidulum CaFl, CaTa, CnLo, FlA, MeMg, NjEg
monochlamys CaTa
pedatum CaEm. CaFl. CaR, CnRh, CnWf. IlLg, InHe. KaTp, MaAa, MaBg, MaLe. MdBm, MeRg, MnFe, MnOg, NcBr, NcTl, NhFs, NhSk, NjMi, OhWm, PaLl, PaVw, TeBe, WaLc, WaLn, WiWa
——var. aleuticum MaLe, WaLc, WaWi
peruvianum CaTa
raddianum CaEm, CaFl, CaTa, KaTp, NjR, ScGp
——'Bridal Veil' CaTa
——'Charlottae Parvifolium' CaTa
——'Dissected Leaflet' CaTa
——'Elegans' CaTa
——'Fragrantissimum' CaFl
——'Fritz Luth' CaTa, KaTp
——'Gracillimum' CaTa, FlA
——'Lady Geneva' CaTa
——'Lambertianum' CaTa
——'Lawsonianum' CaTa
——'Legrand Morgan' CaTa
——'Micropinnulum' CaTa
——'Multiceptum' CaTa
——'Ocean Spray' ScGp
——'Pacific Maid' CaFl, CaTa, MeMg, NjEg
——'Robinsons Vari' KaTp
——'Variegated Tesselate' CaTa
——'Variegatum' CaTa
tenerum 'Farleyense' CaTa
——'Fergusonii' CaTa
——'Gloriosum' CaTa, NjEg
——'Lady Moxham' CaTa
——'Marsha's Pride' CaTa
——'Rosetta' CaTa
——'Wrightii' CaFl, FlA, NjEg, NjR
venustum MeRg
'Bridal Veil' CaTa
'Marconii' CaTa
'Sleeping Beauty' CaTa
AGLAOMORPHA
coronans, CaCj, CaEm, CaFl, FlA, KaTp, NjR
heraclea CaFl, CaTa, KaTp, NjR
meyeniana CaCj, CaTa, FlA, KaTp, NjEg, NjR, TxNh
ALSOPHILA
cooperi CaEm, CaFl, KaTp, TxNh

ASPLENIUM
antiquum CaTa
bulbiferum CaEm, CaFl, CnLo, KaTp, MeMg, NjEg, NjR, TxNh
capense CaEm
marinum CaTa
mayi CaTa
myriophyllum CaTa
nidus CaFl, CaTa, FlA, KaTp, MeMg, NjEg, NjR, ScGp
——'Australianum' CaTa
oligophlebium CaTa
platyneuron AlFh, CnRh, IlLg, InHe, MaAa, MaBg, MaLe, MdBm, MeRg, NcBr, NcTl, NhFs, NjMi, PaVw, TeBe, TxNh
ruta-muraria WaLc
sarelii CaTa
trichomanes InHe, MaAa, MaLe, MeRg, NcBr, NhFs, PaVw, WaJv, WaLc
——'Incisum' WaWi
viviparum CaTa, FlA, KaTp, NjEg
ATHYRIUM
americanum CaR
asplenioides TeBe
filix-femina AlFh, CnRh, CnWf, IlLg, InHe, KaTp, MaLe, MdBm, MnFe, MnOg, NcBr, NhFs, NhSk, NjMi, OhSh, OhWm, PaLl, PaVw, WaJv, WaLn, WaWi, WiWa
——var. rubellum MnOg
——cvs. OrKf
goeringianum var. pictum MaLe, MeRg, MiRk, WaWi
pycnocarpon InHe, MaLe, NcTl, NhFs
thelypterioides CnRh, CnWf, IlLg, InHe, MaBg, MaLe, NhFs, NjMi
BLECHNUM
brasiliense CaFl, FlA, KaTp
gibbum CaFl, KaTp
moorei CaEm, CaFl, FlA
penna-marina WaLc, WaWi
spicant CaEm, WaLc. WaWi
unilaterale KaTp
BOTRYCHIUM
dissectum var. obliquum AlFh
virginianum AlFh, IlLg, InHe, MaLe, MnOg, NcBr, NhFs, NhSk, TeBe
CAMPTOSORUS
rhizophyllus CnRh, InHe, MaAa, MaBg, MaLe, MeRg, NcBr, NcTl, NjMi, PaVw, TeBe
CETERACH
officinarum WaLc, WaWi
CHEILANTHES
gracillima WaLc, WaWi
siliquosa WaLc, WaWi
tomentosa WaLc, WaWi
CIBOTIUM
barometz CaFl
chamissoi CaEm, CaFl
schiedei CaEm, CaFl, NjR
CRYPTOGRAMMA
acrostichoides WaLc, WaWi
CTENITIS
pentangularis CaFl
CYATHEA
arborea NjR
medullaris CaEm, CaFl
CYRTOMIUM
caryotideum CaTa
falcatum CaEm, CaFl, CnLo, KaTp, NjEg, TxNh
——'Cristatum' CaTa, KaTp
——'Rochefordianum' CaFl, FlA, MeMg, NjR
CYSTOPTERIS
bulbifera CnRh, MaBg, MnOg, NcBr, NhFs, NjMi, WaJv
fragilis CnRh, NcTl, WaJv, WaWi
DAVALLIA
bullata CaFl
canariensis FlA
fejeensis CaFl, CaTa, FlA, MeMg, MiRk. NjEg, NjR
——var. major CaFl, CaTa
——'Minor' CaTa
——'Plumosa' CaFl, CnLo, MeMg, NjR
griffithiana MeMg, NjEg, NjR
mariesii CaFl, CnLo, MeMg, NjEg
pentaphylla CnLo, NjEg, NjR
plumosa NjEg
solida CaTa, CnLo, MeMg, NjEg, NjR
tenuifolia CnLo
trichomanoides CaEm, CaFl, NjEg, NjR
'Bongo Bongo' CaTa
'Portugal' CaTa
DENNSTAEDTIA
punctilobula IlLg, InHe, KaTp, MaBg, MaLe, MdBm, NcBr, NcTl, NhFs, NhSk, NjMi, OhWm, PaLl, PaVw, TeBe, WaLn
DICKSONIA
antarctica CaEm, CaFl, KaTp
squarrosa CaEm
DIPLAZIUM
lanceum NjR
DOODIA
media CaTa
DRYNARIA
quercifolia CaFl
rigidula CaTa
——var. whitei CaTa

DRYOPTERIS
boottii MaLe
clintoniana NhFs
cristata CnRh, IlLg, MaBg, MaLe, MnOg, NhFs, NhSk
dentata CaFl
dilatata WaWi
elegans KaTp
erythrosora CaEm, MaLe, TxNh
extensa NjEg
filix-mas CaFl, InHe, MaLe, NcBr, NcTl
——'Crispa' WaWi
——'Cristata' CaFl
——'Polydactyla' CaFl
——cvs. OrKf
goldiana MaBg, MaLe, NcBr, NcTl, NhFs, NjMi, WiWa
intermedia × spinulosa MnOg
marginalis CnRh, CnWf, InHe, MaAa. MaBg, MaLe, MdBm, NcBr, NcTl, NhFs, NhSk, NjMi, PaLl, PaVw, OhSh, TeBe, WiWa
oregana WaWi
spinulosa CnRh, CnWf, IlLg, InHe, MaBg, MaLe, MnOg, NcBr, NcTl, NhFs, NhSk, OhWm, WiWa
GYMNOCARPIUM
dryopteris CnRh, IlLg, MaLe, MnOg, NjMi, NhFs, WaWi, InHe
HEMIONITIS
palmata NjEg
HUMATA
tyermannii CaFl, CaTa, CnLo
LEMMAPHYLLUM
microphyllum CaTa, WaLc
LEPISORUS
clathratus CaTa
onoei WaLc
thunbergianus CaTa, WaLc
usuriensis WaLc
LYCOPODIUM
annotinum MnOg
clavatum MnOg
lucidulum MaAa, MnOg
obscurum MnOg, TeBe
selago TeBe
tristachyum TeBe
LYGODIUM
flexuosum CaTa
japonicum CaEm, KaTp
palmatum InHe, MaBg, MaLe, NcBr
MATTEUCCIA
pensylvanica CnRh, CnWf, IlLg, InHe, KaTp, MaBg, MaLe, MdBm, MnFe, MnOg, NcBr, NcTl, NhFs, NhSk, NjMi, OhSh, OhWm, PaVw, WaLn, WiWa
MICROLEPIA
platyphylla CaEm
pyramidata CaTa
speluncae KaTp
strigosa CaEm, CaFl, KaTp, NjEg
MICROSORIUM
buergerianum CaTa
diversifolium CaFl
musifolium CaTa
NEPHROLEPIS
biserrata 'Furcans' FlA, KaTp
cordifolia CnLo
——var. duffii CaTa, CnLo, NjEg, NjR
——'Plumosa' CnLo, KaTp, NjEg, NjR
exaltata CaEm, CaFl, KaTp
——var. bostoniensis CaEm, CaFl, CnLo, MeMg, ScGp
——'Childsii' CaFl, CaTa, FlA
——'Compacta' CaEm, CnLo, MeMg, NjR
——'Dorothy T.' CaTa
——'Dryeri' NjEg
——'Elegantissima' CaFl, CaTa, CnLo, NjEg
——'Fluffy Ruffles' CaTa, CnLo, FlA, KaTp, MeMg, MiRk, NjR
——'Gloriosa' CaTa
——'Hillsii' CaTa
——'M. D. Mills' CaFl
——'M. P. Mills' CaTa
——'Norwoodii' CaFl, CaTa, CnLo, FlA, KaTp, NjEg
——'Ostrich Plume' CaTa
——'Piersonii' CaTa
——'Rooseveltii Plumosa' CaEm, CaFl, NjEg
——'Smithii' CaTa KaTp
——'Splendida' CaFl, CaTa
——'Trevillian' CaTa
——'Verona' CaTa, CnLo, FlA, KaTp, MeMg, NjEg, NjR
——'Wanamaka' CaTa
——'Whitmanii' CaEm, CaFl, CaTa, CnLo, FlA, KaTp, NjEg, NjR
'Fantasia' CaTa
'Fosteri' CaTa
'Marshalii' CaTa
'Selecta' CaTa
ONOCLEA
sensibilis CnRh, IlLg, InHe, KaTp, MaBg, MnFe, MnOg, NcBr, NcTl, NhFs, NhSk, NjMi, OhWm, PaVw
ONYCHIUM
japonicum CaEm
OSMUNDA
cinnamomea CnRh, CnWf, IlLg, InHe, KaTp,

OSMUNDA, cont.

MaBg, MaLe, MdBm, MnFe, MnOg, NcBr, NcTl, NhFs, NhSk, NjMi, OhWm, PaLl, PaVw, TeBe
claytoniana CnRh, IlLg, InHe, KaTp, MaBg, MaLe, MdBm, MnFe, MnOg, NcBr, NcTl, NhFs, NhSk, NjMi, OhWm, PaVw, TeBe
regalis CnRh, CnWf, IlLg, InHe, MaBg, MaLe, MdBm, NcBr, NhFs, NhSk, NjMi, PaLl, PaVw, TeBe, WaJv

PELLAEA
adiantoides CaFl, MeMg
atropurpurea CnRh, MaLe, NcBr, TeBe
falcata CaEm, CaFl, CaTa
hastata CaFl
macrophylla NjEg
rotundifolia CaEm, CaFl, CaTa, CnLo, MeMg, NjEg, NjR
viridis NjR

PHEGOPTERIS
connectilis CnRh, MaLe, MnOg, NcTl, NhFs, NhSk
hexagonoptera AlFh, CnRh, InHe, MaLe, MdBm, NcBr, NhFs, NjMi, PaVw

PHLEBODIUM
aureum CaFl, KaTp, MeMg, NjEg
——'Cristatum' CaFl, CaTa, KaTp
——'Mandaianum' CaEm, CaFl, CnLo, KaTp, NjEg, NjR
——'Mayi' CaFl, KaTp
——'Sporadocarpum, CaFl

PHYLLITIS
scolopendrium CaEm, CaFl, KaTp, MdBm, NjMi, WaWi
——'Crispum' FlA, NjEg, WaWi
——'Cristatum' CnLo
——'Marginatum' WaWi
——'Ramo-cristatum' WaWi

PITYROGRAMMA
× hybrida CaEm, CaFl, KaTp, TxNh

PLATYCERIUM
andinum NjR
angolense CaCj
bifurcatum CaEm, CaTa, CaWo, CnLo, FlA, KaTp, MeMg, NjR
——'Majus' KaTp
——'Netherlands' FlA, NjR
——'San Diego' CaTa, CaWo, FlA
——'Ziesenhenne' FlA
coronarium CaCj, NjR
ellisii CaCj
grande CaTa, CaWo, FlA, KaTp, NjR
——var. tamburinense CaTa
hillii CaCj, CaTa, CaWo, KaTp, NjEg, NjR
——'Drummond' CaWo
× lemoinei CaCj, NjR
madagascariense CaCj
pumilum CaCj, CaTa, FlA
quadridichotomum CaCj
stemmaria CaCj, CaTa, FlA, NjEg
sumbawense CaCj
vassei CaCj, CaTa, FlA
veitchii CaCj, CaWo, FlA, KaTp
wallichii CaWo
wandae NjR
willinckii CaCj, FlA
——'Lemoinei' FlA
——'Payton' CaTa
'Eppley' CaTa
'Martin' CaTa
'Mauna Loa' CaTa
'Panama' CaTa
'South Seas' CaTa
'Splendens' CaTa

POLYPODIUM
decumanum CaCj
integrifolium 'Cristatum' CaTa
lepidopteris CnLo
loriceum CaTa
lowei CaTa
lycopodioides CaTa, CnLo
piloselloides CaTa
polycarpon CaFl, FlA, NjR
——'Grandiceps' CaFl, CaTa, FlA, KaTp, MeMg, NjR
polypodioides AlFh, NcTl, TeBe
scouleri WaLc
squamulosum CaTa
subauriculatum CaFl, KaTp, NjR
——'Knightii' CaFl, CaTa, FlA, KaTp, MeMg, NjEg
vacciniifolium CaTa, CnLo
vulgare CaFl, CnRh, IlLg, InHe, MaAa, MaBg, MaLe, MeRg, MnFe, NcBr, NcTl, NhFs, NhSk, NjMi, PaVw, TeBe, WaLc, WaWi
——var. hesperium WaLc
——'Malahatensis' WaWi
——'Pulcherrimum' WaWi
——'Sempervivoides' WaWi
'Brazilian Giant' CaTa
'Caetesptum' CaTa
'Cambricoides' CaTa
'Elegans' CaTa
'Mt. Elgon' CaTa

POLYSTICHUM
acrostichoides AlFh, CnLo, CnRh, CnWf, IlLg, InHe, KaTp, MaAa, MaBg, MaLe, MnFe, NcBr, NcTl, NhFs, NhSk, NjMi,

POLYSTICHUM, cont.

OhWm, OhSh, PaLl, PaVw, TeBe, WaLn, WiWa
aculeatum CaFl, CnLo, KaTp, MeMg, WaLn
——'Densum' CaEm, KaTp
——'Proliferum' CnLo
adiantiforme CaFl, FlA, KaTp, MeMg
andersonii WaLc, WaWi
braunii MaLe, NhFs
lemmonii CaR, WaWi
lonchitis MaLe, WaJv
munitum CaEm, CaR, WaJv, WaLc, WaWi
——var. imbricans CaR, WaWi
setosum CaEm, FlA, KaTp
tsus-simense CaFl, FlA, NjEg, NjR
viviparum CaFl, NjEg

PTERIDIUM
aquilinum IlLg, InHe, MaBg, MaLe, MnOg, NcBr, NcTl
——var. pubescens WaWi

PTERIS
cretica CaFl
——'Albolineata' NjEg, NjR, ScGp
——'Childsii' CaTa
——'Ouvrardii' CaEm
ensiformis 'Rivertoniana' NjEg, NjR
——'Victoriae' FlA, KaTp, NjEg, NjR
——'Wilsonii' NjEg, NjR
——'Wimsettii' KaTp, NjEg, NjR
flabellata CaFl
longifolia KaTp
major CaFl, NjEg
multifida CaTa
quadriaurita 'Argyraea' CaEm, CaFl, KaTp, NjR
——'Flabellata' NjR
semipinnata NjR
tremula CaEm, CaFl, FlA, KaTp, NjEg, NjR
vittata CaEm

PYRROSIA
lingua CaEm, CaFl, CaTa, CnLo, KaTp
polydactyla CaTa
stigmosa CaWo

RUMOHRA
adiantiformis CaFl, FlA, KaTp, MeMg

SADLERIA
cyatheoides CaEm

SELAGINELLA
caulescens WaWi
eremophila WaWi
haematodes CnLo
inaequalifolia CnLo
involvens WaWi
——'Fuku-mishiki' WaWi
——'Kinkazan' WaWi
——'Nishikigi' WaWi
——'Tatsunani' WaWi
kraussiana FlA, NjR
——'Aurea' CnLo, MeMg
——'Brownii' MeMg, NjR
martensii 'Variegata' CnLo
pallescens FlA, NjEg
spathiphylla CnLo
uncinata CnLo, FlA
vogelii CnLo
wallacei WaWi
willdenovii FlA

STENOCHLAENA
palustris CaFl, CaTa, KaTp

TECTARIA
cicutaria CaFl

THELYPTERIS
noveboracensis CnRh, InHe, MaLe, MdBm, NcBr, NhFs, NhSk, NjMi, PaVw
palustris AlFh, IlLg, InHe, MaBg, MaLe, MnOg, NcBr, NcTl, NhFs, NhSk
setigera CaFl

TODEA
barbara CaEm

TRICHOMANES
radicans TeBe

WOODSIA
ilvensis CnRh, MaAa, MaLe, MeRg, NhFs, WiWa
obtusa CnRh, IlLg, MaBg, MaLe
oregana CaR

WOODWARDIA
areolata AlFh, NjMi
fimbriata CaEm
orientalis CaEm, CaFl, FlA, KaTp
radicans CaEm
virginica IlLg, MaBg, MaLe, NcBr, NhFs

Preliminary Systematic Studies of the Oak Ferns: Chromatography and Electrophoresis

JEANETTE C. OLIVER*

The Oak Ferns, represented in the United States by *Gymnocarpium dryopteris*, *G. robertianum*, and their putative hybrid, have been placed in many different genera. Some authors have placed them in the genus *Dryopteris*, primarily on the basis of similarities in rachis characters and rhizome scaliness. Others have included them with the Beech Ferns (*Phegopteris*). The Beech Ferns and the Oak Ferns have in common an elongate creeping rhizome and exindusiate sori (Morton, 1950). Slosson placed them both in the cosmopolitan genus *Thelypteris*, along with the Marsh Ferns (Wherry, 1961, p. 64). Ching (1933) proposed that the Oak Ferns be regarded as a genus distinct from *Phegopteris*, and he redefined *Gymnocarpium*. Currently most workers appear to favor this interpretation; however, other combinations are frequently used, particularly in local and regional floras.

Cytological studies have shown a similarity in chromosome size between the Oak Ferns and the Beech Ferns; however, the number differs. The base number of 40 is found in the Oak Ferns (Wagner, 1966). The Broad Beech Fern and the Long Beech Fern have numbers of 30 and 90, respectively (Britton, 1965; Manton, 1950, p. 184). True *Dryopteris* has a base number of 41 chromosomes (Walker, 1961; 1962). These chromosomes tend to be somewhat larger than those of either the Beech or the Oak Ferns. Chromosome numbers vary within the genus *Thelypteris*; however, none reported correspond with that of the Oak Ferns.

In recent years paper chromatography has gained acceptance as a taxonomic method. Most of the studies have involved taxa at or below the species level. The works of Smith and Levin (1963), Alston and Turner (1963), and others have indicated chromatography to be of particular value in the confirmation of interspecific hybridization. Works with higher taxa have concerned primarily the distribution and occurrence of specific compounds (Kupchan et al. 1961; Mabry et al. 1963).

Cellulose acetate electrophoresis has been used in animal taxonomy (Leviton et al. 1964). No reports were located of comparable comparative studies in plants, though immunoelectrophoresis studies have been done with various plant taxa (Gell et al. 1956).

This study was undertaken to add further information concerning the status of the Oak Ferns by the consideration of biochemical characteristics, and to explore the value of paper chromatography and cellulose acetate electrophoresis in generic problems.

Chromatographs and electrophoretographs of extracts from the Oak Ferns were compared with those of representatives of the Beech Ferns, the Marsh Ferns (*Thelypteris*), and the Wood Ferns (*Dryopteris*).

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METHODS AND MATERIALS

Extensive collections of the ferns were made throughout Indiana, Ohio, Minnesota, and Wisconsin. Voucher specimens were deposited in the Ball State University Herbarium. Two populations of *Gymnocarpium robertianum* were sampled. The remaining species were represented by ten populations each. Twenty-five chromatograms and ten electrophoresis membranes were prepared for each population.

Extracts were prepared by powdering dried fronds and soaking the materials in methanol : hydrochloric acid : water (7.9 : 0.1 : 2.0) for 48 hours. Paper chromatograms were prepared by applying fifty microliters of each sample to Whatman #1 paper using the spot method. The chromatographs were run descendingly using butanol : acetic acid : water (12 : 3 : 5) as the solvent.

Dried chromatograms were examined in the presence of long wave ultraviolet light and ammonia vapor. The chromatograms were sprayed with ninhydrin for the detection of free-amino acids and related substances, and alkaline silver nitrate, a general reagent for the detection of phenolic compounds (Smith, 1958). Average rf values were calculated for the spots detected.

Electrophoresis studies were made using a Buchler migration chamber and Buchler cellulose acetate strips measuring one by six inches. Ten microliters of extract were applied with a streaking pipette at the center of each strip and migrations were allowed to proceed for one hour. The electrophoretic runs were conducted at 200 volts and five milliamperes in a double veronal buffer of pH 8.6. Electrophoresis patterns were observed under of long wave ultraviolet light.

Extracts of *Gymnocarpium dryopteris* and *G. robertianum* were compared chromatographically and electrophoretically with those of *Phegopteris polypodioides*, *P. hexagonoptera*, *Thelypteris noveboracensis*, *T. palustris*, *Dryopteris marginalis*, and *D. spinulosa*.

RESULTS

Chromatographs examined in the presence of long wave ultraviolet light in combination with ammonia vapor revealed little similarity between the Oak Ferns and the others with which they have been grouped (*Fig. 1*). The fluorescent substances were indicated by their positive reactions with alkaline silver nitrate to be phenolic in composition. One compound (labelled 5) with an rf value of 0.67 was common to all species. Several compounds appeared to be genus specific. Five compounds (labelled 4) with rf values of 0.16, 0.32, 0.40, 0.80 and 0.89 were specific to *Dryopteris marginalis* and *D. spinulosa*. Compounds (labelled 3) with rf values of 0.14, 0.38, 0.48, 0.80 and 0.89 were characteristic of *Thelypteris palustris* and *T. noveboracensis*. *Phegopteris* was characterized by spots (labelled 2) with rf values of 0.35, 0.49, and 0.91. Six compounds (labelled 1) with rf values of 0.15, 0.28, 0.40, 0.55, 0.78, and 0.90 were detected in *Gymnocarpium* exclusively. A few phenolics which appeared to be species specific were noted in all ferns considered.

Some chromatograms were sprayed with ninhydrin. Little could be derived concerning generic relationships, as most ninhydrin positive compounds either were shared by all ferns sampled or were species specific (*Fig. 2*).

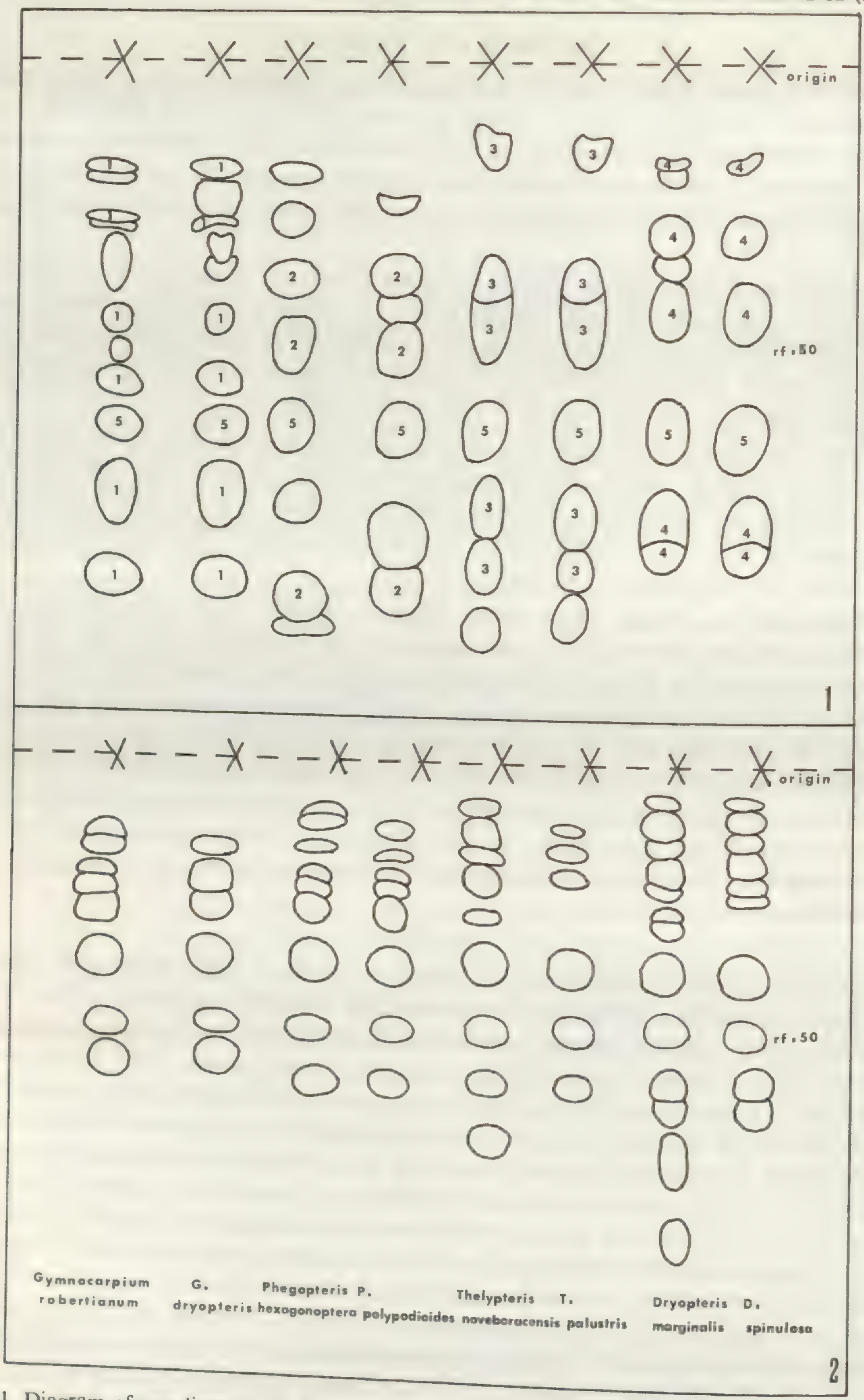

Fig. 1. Diagram of one-dimensional descending chromatograph under long wave UV and ammonia vapor, × 0.2. Fig. 2. Diagram of one-dimensional descending chromatograph under long wave UV and ninhydrin, × 0.2.

Cellulose acetate electrophoresis membranes were observed in the presence of long wave ultraviolet light (*Fig. 3*). All constituents migrated toward the positive pole. The bands were phenolic or amino acid in nature due to the method of extract preparation; however, the exact constituency of each band was not determined.

The patterns obtained were quite distinctive within each genus. *Dryopteris marginalis* and *D. spinulosa* shared green and blue fluorescent bands. Three common bands, avocado, blue-violet, and green, were noted in *Thelypteris noveboracensis* and *T. palustris*. The genus *Phegopteris* was characterized by two, specific, blue and blue-violet bands. Two additional species-specific green bands were seen in *P. polypodioides*. Distinctive blue-violet and yellow bands were seen in the Oak Ferns. These did not correspond with those of the other genera.

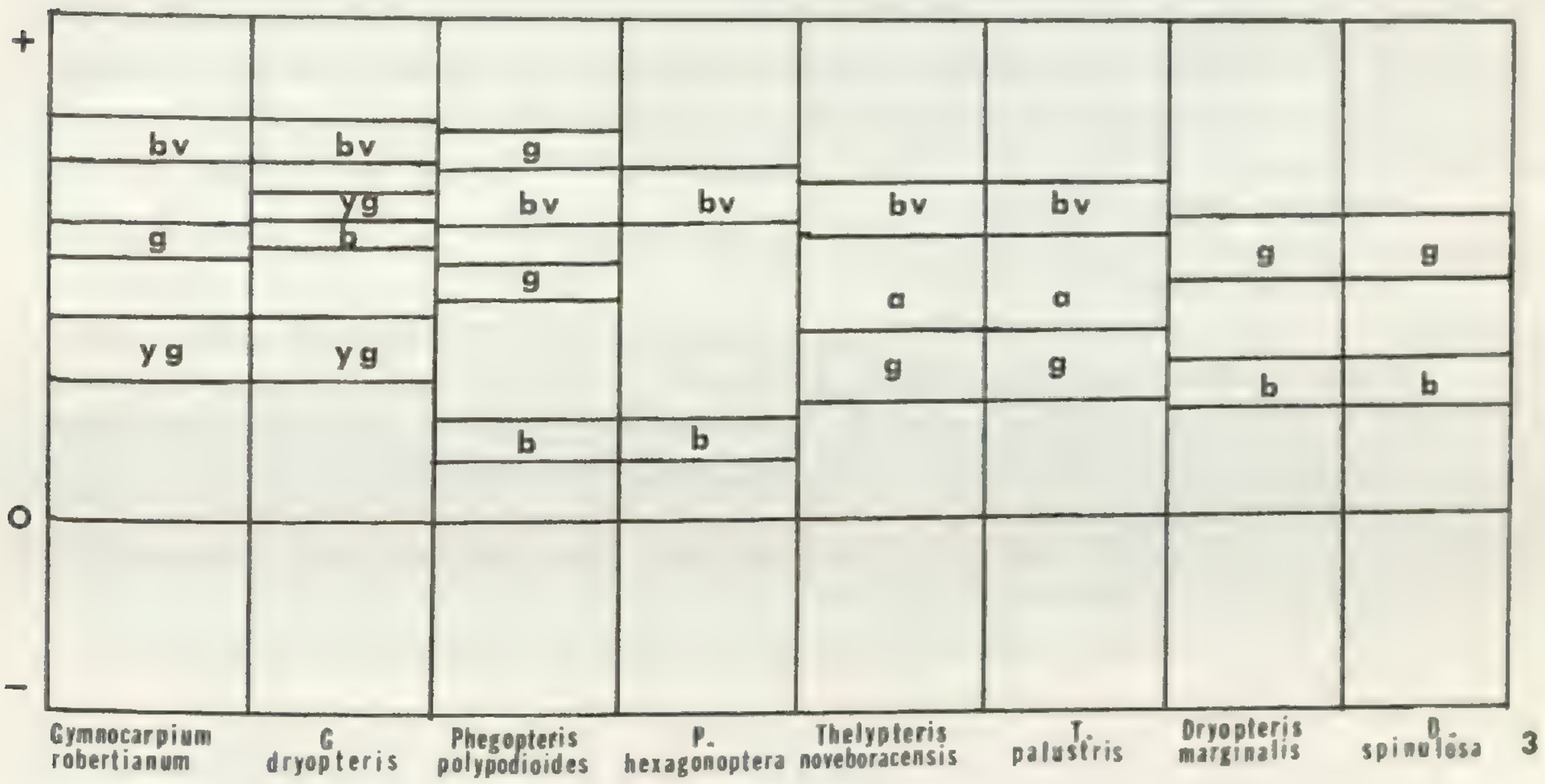

Fig. 3. Drawing of cellulose acetate electrophoresis membrane under long wave UV. × 0.35.

DISCUSSION

The application of paper chromatography in studies at the generic level appears promising. Significant affinities were not indicated in chromatographic patterns of the phenolics of the Oak Ferns with those of representatives of *Dryopteris*, *Thelypteris*, and *Phegopteris*. Free amino acid patterns were very similar, however, for all ferns sampled.

The band patterns derived by cellulose acetate electrophoresis were distinctive for each genus. Cellulose acetate electrophoresis has the advantages of ease of preparation and rapid migration. Some limitations of the method were indicated, however. Samples of the same extracts were used for both chromatography and electrophoresis. There were more compounds detected on the chromatograms than on the strips; thus, an incomplete separation and resolution by cellulose acetate electrophoresis is apparent. Further, many indicator reagents which are useful with paper cause distortion of the cellulose acetate membranes. As a means of

complete separation and identification of components the technique appears limited.

Additional studies of this nature must be done before a completely objective assessment of the validity of the methods can be attained.

Many problems of generic delimitation exist among the thelypteroid and dryopteroid ferns. Additional studies involving related species from North America and other continents (cf. Holttum, 1971) must be undertaken before a complete taxonomic understanding can be gained.

LITERATURE CITED

ALSTON, R. D. and B. L. TURNER. 1963. Natural hybridization among four species of Baptisia (Leguminosae). Amer. J. Bot. **50:** 159–173.

BRITTON, D. M. 1965. The cytology and distribution of Dryopteris species in Ontario. Canad. J. Bot. **44:** 63–78.

CHING, R. C. 1933. On the nomenclature and systematic position of Polypodium Dryopteris L. and related species. Contr. Biol. Lab. Sci. Soc. China **9:** 30–43.

GELL, P. G. H., S. T. C. WRIGHT, and J. G. HAWKES. 1956. Immunological methods in plant taxonomy. Nature **177:** 573.

HOLTTUM, R. E. 1971. Studies in the family Thelypteridaceae III. A new system of genera in the Old World. Blumea **19:** 17–52.

KUPCHAN, S. M., J. H. ZIMMERMAN, and A. AFONSO. 1961. The alkaloids and taxonomy of Veratrum and related genera. Lloydia **24:** 1–26.

LEVITON, A. E., G. S. MYERS, and B. W. GRUNBAUM. 1964. An electrophoretic survey of rattlesnake venoms. Pp. 667–671 *in* C. A. Leone, Taxonomic biochemistry and serology. Ronald Press, New York.

MABRY, T. J., A. TAYLOR, and B. L. TURNER. 1963. The betacyanins and their distribution. Phytochem. **2:** 61–64.

MANTON, I. 1950. Problems of cytology and evolution in the Pteridophyta. University Press, Cambridge, Eng.

MORTON, C. V. 1950. Notes on the ferns of the eastern United States. Amer. Fern J. **40:** 213–225.

SMITH, D. M. and D. A. LEVIN. 1963. A chromatographic study of reticulate evolution in the Appalachian Asplenium complex. Amer. J. Bot. **50:** 952–958.

SMITH, I. 1958. Chromatographic techniques: Clinical and biochemical application. Heinemann Medical Books, London.

WAGNER, W. H., JR. 1966. New data on North American oak ferns, Gymnocarpium. Rhodora **68:** 121–137.

WALKER, S. 1961. Cytogenetic studies in the Dryopteris spinulosa complex II. Amer. J. Bot. **48:** 607–614.

WALKER, S. 1962. Further studies in the genus Dryopteris; the origin of D. clintoniana, D. celsa and related taxa. Amer. J. Bot. **49:** 497–503.

WHERRY, E. T. 1961. The fern guide. Doubleday, Garden City, New York.

Notes on Pellaea glabella and Polystichum scopulinum

ROBERT D. DORN*

Pellaea glabella Mett. ex Kuhn var. *simplex* Butters and *P. glabella* var. *occidentalis* (E. Nels.) Butters have not previously been known to overlap in their distributions (Tryon, 1957; Tryon & Britton, 1958). Two stations for var. *simplex* were found this past summer in the range of var. *occidentalis*. The collections are *Dorn 1354* (RM) from Teton County in northwestern Wyoming and *Dorn 1455* (RM) from Crook County in northeastern Wyoming. The collected plants have 32 spores per sporangium (var. *occidentalis* has 64 spores per sporangium) and have the morphological characters of var. *simplex*. Both varieties were found within 30 meters of each other at the Teton County station.

Polystichum scopulinum (D. C. Eaton) Maxon has not previously been considered to occur in Wyoming. Actually, the type locality is in Wyoming. Eaton (1880) gave the locality as Upper Teton Cañon in eastern Idaho. The type specimen was collected on a Hayden expedition, and Hayden's (1873) report leaves no doubt that the type locality is Upper Teton Cañon, Teton County, Wyoming. The Idaho border runs perpendicular to the mouth of the canyon, and so the upper canyon is several miles inside Wyoming, where the Hayden maps show it. Hanna (1932) suggested that the locality was in Wyoming, but did not confirm it.

Fernald (1924) placed *P. scopulinum* under *P. mohrioides* as a variety and quoted a description of the "type region" of *P. scopulinum* from Hayden (1873). The description is probably not of the type locality, because the plant was collected on July 28 but the description is for the party's activities on July 29. I attempted to relocate the species, but was unsuccessful due to the extensive area and abundant potential habitat.

Another Wyoming collection of *P. scopulinum* is in the Yellowstone National Park Herbarium (*M. T. Doutt 155*, July 20, 1930). It was collected in the Bechler River Canyon, Yellowstone Park, Wyoming. The Bechler River Canyon is about 40 miles north of the type locality.

LITERATURE CITED

EATON, D. C. 1880. Ferns of North America, Vol. II. S. E. Cassino, Boston, Mass. xxxi + 285 pp.

FERNALD, M. L. 1924. Polystichum mohrioides and some other subantarctic or Andean plants in the northern hemisphere. Rhodora **26:** 89–95.

HANNA, L. A. 1932. Distribution of the ferns of Wyoming. Amer. Fern J. **22:** 1–11.

HAYDEN, F. V. 1873. Sixth annual report of the United States Geological Survey of the territories. Gov. Prtg. Off., Washington, D. C. xi + 844 pp.

TRYON, ALICE F. 1957. A revision of the fern genus Pellaea section Pellaea. Ann. Mo. Bot. Gard. **44:** 125–193.

———, and D. M. BRITTON. 1958. Cytotaxonomic studies on the fern genus Pellaea. Evolution **12:** 137–145.

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A Report of Fall-fruiting Plants of Ophioglossum engelmannii Prantl in Eastern Kansas

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The fruiting time of *Ophioglossum engelmannii* Prantl, Engelmann's Adder's-tongue, has been reported in various manuals as occurring during mid-April to early June. Although Palmer (1932) stated that in the Ozarks in a wet autumn a second vegetative growth occurs, he made no mention of fruiting structures. In eastern Kansas, we have found that *O. engelmannii* commonly produces both vegetative and fertile fronds not only during the spring and early summer, but also in the fall season from late August to early November. *Table 1* summarizes the data obtained from one to several quadrats, each one m^2, taken at each site from the colonies indicated, both in the fall of 1970 and the spring of 1971.

TABLE 1. PERCENTAGES OF FERTILE FRONDS

Location	*Fall, 1970*		*Spring, 1971*	
	No. of plants	*No. fertile*	*No. of plants*	*No. fertile*
Anderson County				
North Garnett City Park	209	9	82	14
3.5 mi SW of Garnett	153	53	192	25
4 mi S of Garnett	132	4	—	—
Allen County				
0.8 mi N of Neosho-Allen County line on US 169	143	22	384	101
Bourbon County				
Bourbon County State Park, 4.4 mi E of Elsmore	43	3	107	15
2.5 mi E, 1.4 mi S of Hiattville	10	3	72	41
Miami County				
Miami County State Park	19	6	—	—
Elk County				
3 mi W of Elk Falls	108	14	—	—
Totals	817	114 (13.9%)	837	196 (23.4%)

The following list of representative specimens (all in KANU) indicates that fall-fruiting in *O. engelmannii* is relatively common within the range of the species in Kansas.

Allen County: 0.8 mi N of Neosho-Allen County line on US-169, prairie hay meadow, dry loam soil over limestone, 28 Sept 1969, *Magrath 4977;* 5 Oct 1969, *Stephens 37149;* 20 Oct 1970, *Weedon 6908;* 25 Oct 1970, *Magrath & Weedon 6649.*

Anderson County: Garnett, North Garnett City Park, in mowed area, thin clay soil with limestone at the surface, 25 Oct 1970, *Magrath & Weedon 6648;* 3.5 mi SW of Garnett, burned over cedar barren, thin clay loam soil with limestone at the surface, 25 Oct 1970, *Weedon & Magrath 6910;* 4 mi S of Garnett, weedy prairie roadside right-of-way, soil with limestone at the surface, 29 Oct 1970, *Stephens 46705.*

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Bourbon County: Bourbon County State Park, 4.4 mi E of Elsmore, edge of woods along mowed prairie roadside near W side of lake, clay soil over limestone, 25 Oct 1970, *Weedon & Magrath 6912;* 2.5 mi E of Hiattville on K-39, 1.4 mi S on K-7, prairie hay meadow, clay loam soil over limestone, 25 Oct 1970, *Magrath & Weedon 6653.*

Coffey County: 7 mi N, 2.2 mi W of Westphalia, upland prairie pasture, limestone soil, 8 Nov 1970, *Magrath 6645.*

Douglas County: 1.5 mi W of University of Kansas campus, seepy place in blue-grass pasture, 20 Aug 1930, *Horr.*

Elk County: 3 mi W of Elk Falls, weedy prairie pasture, soil with limestone at the surface, 29 Oct 1970, *Stephens 46704.*

Lyon County: Reading Woods area, 0.5 mi W on K-170, 1 mi N, 0.5 mi W of Reading, prairie pasture, limestone soil, 8 Nov 1970, *Magrath 6641.*

Miami County: Miami County State Park, 2.5 mi E of Fontana, open woods hilltop, soil with limestone at the surface, 29 Oct 1970, *Stephens 46707.*

Wilson County: Hands Hill, 3 mi W of Neodesha, rocky brushy prairie pasture, dry limestone soil, 29 Oct 1970, *Stephens 46703.*

We wish to thank Mr. H. A. (Steve) Stephens for contributing data valuable to this study.

LITERATURE CITED

PALMER, E. J. 1932. Notes on Ophioglossum engelmanni. Amer. Fern J. **22:** 43–47.

PETRIK, ALETA J. 1969. Ferns and Fern Allies of Kansas, Nebraska, South and North Dakota. Unpublished Ph.D. Thesis, University of Kansas, Lawrence.

NOTES AND NEWS

ALEXANDRE CURT BRADE, the distinguished pteridologist of Rio de Janeiro, died on July 17, 1971, about a month after celebrating his ninetieth birthday. Dr. Brade specialized in Brazilian ferns, orchids, and melastomes. In recent years he worked exclusively on ferns from the New World tropics, especially those of Brazil. He founded the Herbarium Bradeanum, which contains the originals of his collections, most notably a large number of Costa Rican ferns collected in 1908–1910 and many collected in São Paulo and Minas Gerais. On the occasion of his eighty-fifth birthday, his colleague Dr. G. F. J. Pabst published a resumé of Dr. Brade's interesting life (Taxon **16:** 161–167. 1967). Included there is a bibliography through 1965. A supplement to this has recently been published by Dr. Pabst (Bradea **10:** 69–72. 1971).—*D.B.L.*

Rhizoid Formation in Megagametophytes of Marsilea in Response to Growth Substances

WILLIAM W. BLOOM and KENNETH E. NICHOLS*

In an earlier paper by Bloom (1962), dealing with rhizoid formation in unfertilized megagametophytes of *Marsilea*, it was suggested that rhizoid formation is a geotropic response involving an endogenous auxin. It was suggested that the auxin becomes concentrated in the ventral region of the gametophyte plant as a result of gravitational force. As a result of a series of experiments conducted in our laboratories, further evidence has been gathered to confirm the roles of auxins and gravitational forces in determining rhizoid formation.

Maravolo and Voth (1966) have reported that gemmalings of *Marchantia* normally form ventral rhizoids on new tissue, but that when exogenous auxins are applied and reach a threshold concentration on the dorsal surface, rhizoids form there as well. The number of rhizoids formed was reported to be proportional to the concentration of the exogenous auxin. Miller and Miller (1964) reported effects of auxins on cell enlargement in fern gametophytes of *Onoclea sensibilis*, but did not report any observations of unusual effects on rhizoid formation. Kelley and Postlethwait (1962) studied the effects of the plant growth substance 2-chloroethyltrimethyl-ammonium chloride on gametophytes of *Pteridium aquilinum* and noted an effect on the time sequence of rhizoid production, but did not report any unusual effect on the position of the rhizoids formed.

If auxins are indeed involved in rhizoid formation in the megagametophytes of *Marsilea* and if a higher concentration of auxin at the ventral sites is a response to gravitational force, certain predictions can be made concerning the effect of the application of exogenous auxins to the megagametophytes. In diverse processes auxins are generally stimulatory at certain concentrations and inhibitory at higher concentrations (Leopold, 1964). It could be predicted that rhizoid formation would be inhibited at high concentrations of exogenous auxins and stimulated at low concentrations. An additive effect could be expected if exogenous auxins are applied at very low concentrations.

To test the above hypotheses the following experiments were conducted. Mineral nutrient solutions were prepared using Hoagland's No. 2 solution as given by Hoagland and Arnon (1938), with appropriate micronutrients added. Separate solutions were prepared by adding indole-3-acetic acid, napthalene acetic acid, or gibberellic acid in amounts to provide concentrations by weight of one part in 10,000 (10^{-4}), 100,000 (10^{-5}), 1,000,000 (10^{-6}), and 10,000,000 (10^{-7}). Plain agar was added at a concentration of 1.5% to each solution and the solutions were autoclaved and poured into sterile 100 × 15 mm plastic Petri dishes.

Sporocarps of *Marsilea mucronata* were hydrated in deionized water. As soon as the megaspores were free they were transferred to the surface of the agar plates. Organic materials other than agar were not included in the media since the mega-

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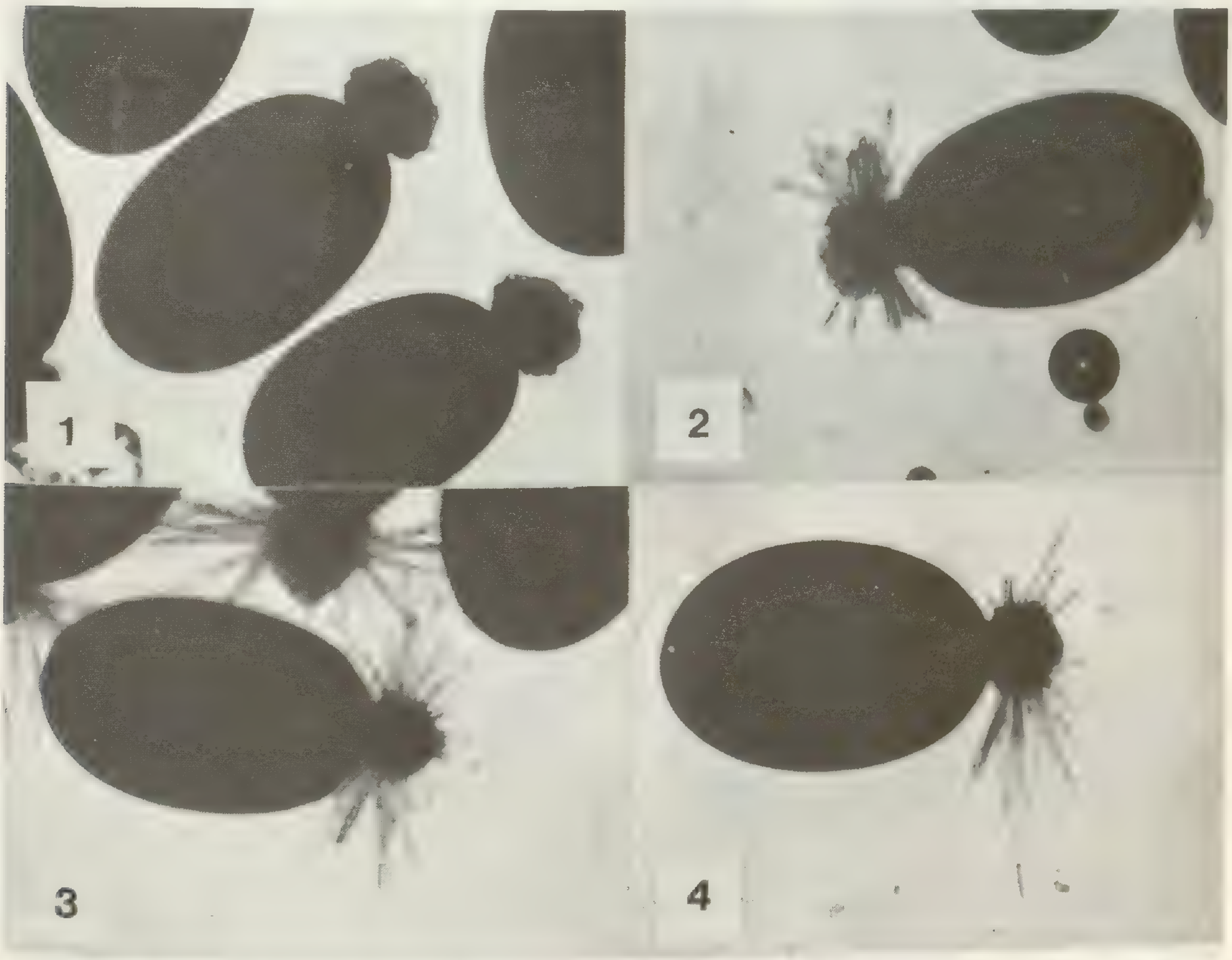
spores contain a considerable amount of food reserve in the form of starch. After the megaspores had been transferred to the agar surface, the plates were changed from a horizontal to a vertical position and marked to indicate the ventral position. One-half of the plates were maintained in constant illumination from cool white fluorescent lights at an intensity of approximately 200 ft-c. The remaining plates were covered with aluminum foil to exclude the light. The laboratory was maintained at a temperature of 24°C during the experiment. At the end of a 49-hour growth period the plates were examined and representative plants were photographed. The megagametophytes were photographed *in situ* after placing a drop of water on the plants and covering them with a cover glass. The pictures were taken with a Bausch & Lomb photobinocular microscope at 80 × with Polaroid 3000 film using a 1.7 filter, iris closed, stop 5 on the illuminator, at 1/5 second.



Figures 1–4. Plants grown on media containing indole-3-acetic acid in concentrations indicated. Fig. 1. 10^{-4}. Fig. 2. 10^{-5}. Fig. 3. 10^{-6}. Fig. 4. 10^{-7}.

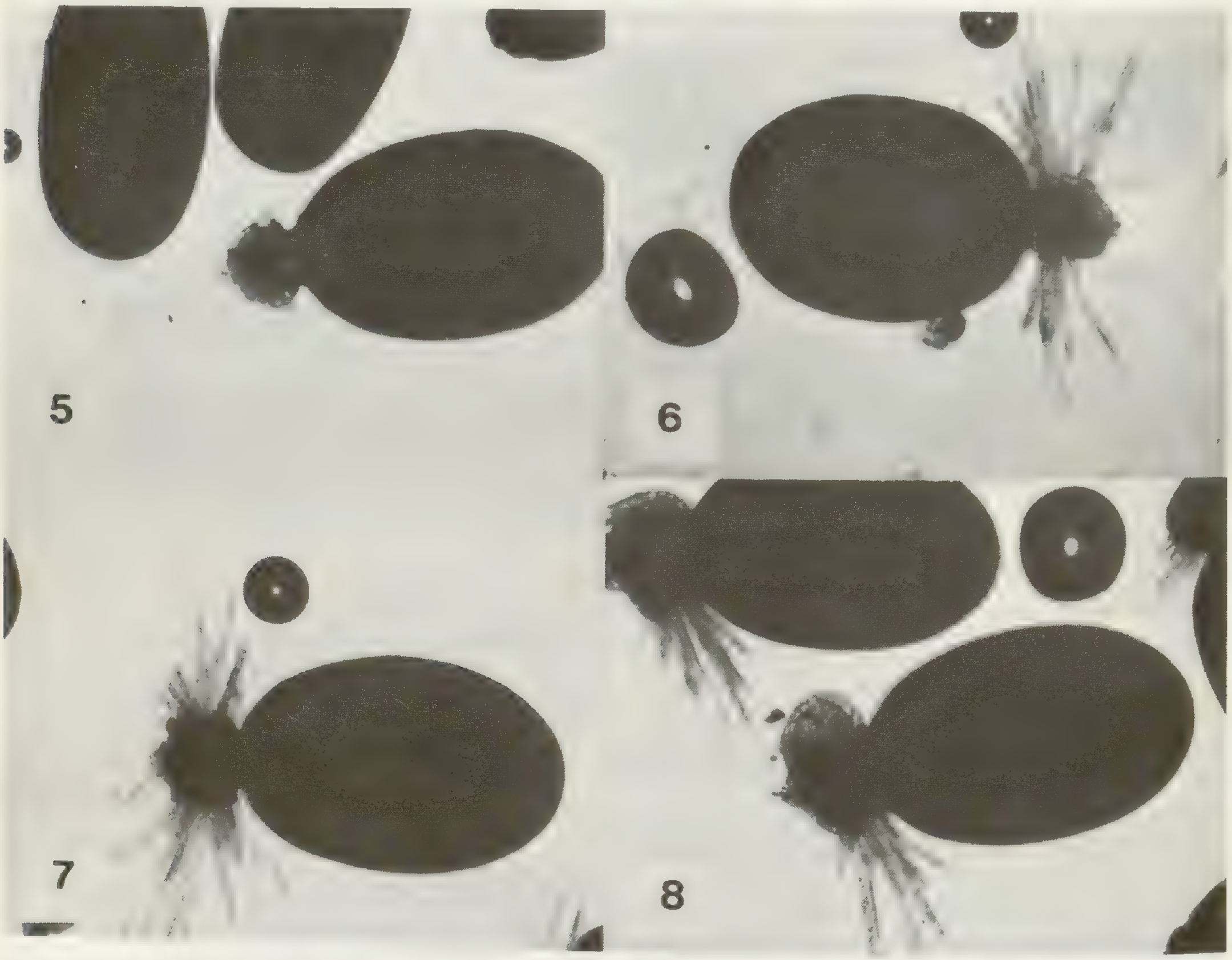
Plants grown on media containing the various concentrations of gibberellic acid were all similar. The rhizoids developed in the ventral portion of the megagametophytes, as also occurred in the controls. Little variation could be detected regardless of the concentration of gibberellic acid. These plants were characteristically a deeper green than the other experimental plants.

Figures 1–4 illustrate the results with plants grown in the dark and treated with concentrations of indole-3-acetic acid as noted in the legend. Concentrations of 10^{-4} were inhibitory (*Fig. 1*); concentrations of 10^{-5} were stimulatory (*Fig. 2*), producing rhizoids on both dorsal and ventral surfaces, but less effectively than concentrations of 10^{-6} (*Fig. 3*); concentrations of 10^{-7} were mildly stimulatory, as

indicated by the short rhizoids on the dorsal surface and additive to endogenous auxins as shown by the longer. more numerous ventral rhizoids (*Fig. 4*).

Figures 5–8 illustrate the results with plants grown in the dark and treated with concentrations of napthalene acetic acid as noted in the legend. Concentrations of 10^{-4} were inhibitory (*Fig. 5*); concentrations of 10^{-5} (*Fig. 6*) and 10^{-6} (*Fig. 7*) were stimulatory; concentrations of 10^{-7} were not stimulatory, as indicated by the absence of rhizoids on the dorsal surface (*Fig. 8*).

Plants grown in the light were generally larger and contained more chlorophyll than the plants grown in the dark. It was not possible at this time to determine whether the increased growth in the light was due to photosynthetic activity or whether light caused an increase in auxin production.



Figures 5–8. Plants grown on media containing napthalene acetic acid in concentrations indicated Fig. 5. 10^{-4}. Fig. 6. 10^{-5}. Fig. 7. 10^{-6}. Fig. 8. 10^{-7}.

LITERATURE CITED

BLOOM, W. W. 1962. Some factors influencing rhizoid formation in female gametophytes of the Marsileaceae. Proc. Indiana Acad. Sci. **72:** 118–119.

HOAGLAND, D. R. and D. I. ARNON. 1938. The water-culture method for growing plants without soil. Univ. Calif. Agric. Expt. Sta. Circ. 347.

KELLEY, A. G. and S. N. POSTLETHWAIT. 1962. Effect of 2-chloroethyltrimethylammonium-chloride on fern gametophytes. Amer. J. Bot. **49:** 778–786.

LEOPOLD, A. C. 1964. Plant growth and development. McGraw-Hill, New York.

MARAVOLO, N. C. and P. D. VOTH. 1966. Morphogenic effects of three growth substances on Marchantia gemmalings. Bot. Gaz. **127**(2–3): 79–86.

MILLER, J. H. and P. M. MILLER. 1964. Effects of auxin on cell enlargement in fern gametophytes: Developmental stages of the cell and response to auxin. Amer. J. Bot. **51:** 431–436.

A Note on the Cytology of Athyrium anisopterum Christ

S. S. BIR*

In most of the major manuals of Indian ferns published between 1860 and 1910 *Athyrium anisopterum* Christ was not separated from *A. puncticaule* (Blume) Moore [= *A. macrocarpum* (Blume) Bedd.]. It was recognized as a separate and distinct species by Alston and Bonner (1956) and by Sledge (1962). What Beddome (1864) called *A. macrocarpum* and the Malayan plant described by Holttum (1954, p. 550; 1968, p. 637) under the same name are both *A. anisopterum*. *Asplenium macrocarpum* var. *atkinsonii* Hook. & Bak. *sensu* Clarke (1880) also belongs here.

Athyrium anisopterum differs from *A. puncticaule* in possessing much smaller (10–20 × 2.5–5 cm), narrowly oblong, simply pinnate fronds with fragile stipes and auriculate, deeply lobed or pinnatifid, membranaceous pinnae. It always prefers moist rocks. *Athyrium puncticaule*, which grows along forest fringes, roadsides, etc., has larger fronds (25–50 × 8-25 cm) with stiff stipes. The pinnae of *A. anisopterum* have the lower base obliquely cut away and the basal acroscopic lobe well developed. They have prominent sori and lacerate indusia.

I have found both diploid and tetraploid sexual plants of *A. anisopterum* in the Himalayas. Sikkim populations (Lachen, alt. 2400 m, *S. S. Bir*, PAN[1] 4051, 4767) are tetraploid with 80 bivalents (*Fig. 1A*); this number was also reported by Mehra and Verma (1957) from Darjeeling. Tetraploid plants were also reported by Manton and Sledge (1954) in Ceylon and by Abraham et al. (1962) at Ponmudi, South India. Diploid plants from Simla (Chadwick falls, alt. 1500 m, *S. S. Bir*, PAN 4039, 4040) and also from Kodaikanal (Silver Cascade, alt. 1650 m, *S. S. Bir*) revealed with unusual clarity 40 bivalents (Bir, 1965) in spore mother cells (*Fig. 2A*). The tetraploids have larger spores than the diploids (*Figs. 1B, 2B*), and the same is true of epidermal cells and stomata. Morphologically the two taxa are distinct, as is evident from comparing silhouettes of the fronds (*Figs. 1C, 2C*). The two can be separated as follows:

DIPLOID PLANTS—Fronds 3 or 4 per plant; stipes 2–5 cm long; laminae broadly lanceolate, 8–15 cm long, 3–4.5 cm wide; pinnae 8–12 pairs excluding the pinnatifid apex, up to 1.5–2.5 cm long with broadly obtuse apex, cut down $^2/_3$ to the midrib into broad segments, the basal acroscopic one not much prominent; sori inconspicuous, few; spores ca. 43 × 37 μ.

TETRAPLOID PLANTS—Fronds 4–12 per plant; stipes 10–15 cm long; laminae narrowly oblong, 10–12 cm long, 2.5–5 cm wide; pinnae 12–15 pairs excluding the pinnatifid apex, up to 0.8–1.5 cm long with narrowly obtuse or acute apex, often cut down $^3/_4$ to the midrib into narrow segments; sori prominent and covering the entire laminar surface, indusia conspicuous; spores ca. 60 × 40 μ.

The morphological characters show that the diploids and tetraploids are distinct and easily separable. They should have separate taxonomic status. The tetra-

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[1] Abbreviation for Panjab University Herbarium, Chandigarh.

ploid matches very closely in all essential aspects an isotype of *A. anisopterum* (US 457597) collected by A. Henry in China, except that it is larger than the specimen that was examined cytologically. The altogether different diploid species will be described and named when herbarium material from other regions is studied in detail.

FIG. 1. *Athyrium anisopterum* (4*x*). FIG. 1A. Spore mother cell at meiosis of plant from Sikkim, $n = 80$. FIG. 1B. Spores. FIG. 1C. Frond of plant from Sikkim which resembles the isotype. FIG. 2. *Athyrium sp.* (2*x*). FIG. 2A. Spore mother cell at diakinesis of plant from Kodaikanal, $n = 40$. FIG. 2B. Spores. FIG. 2C. Frond of plant from Simla.

LITERATURE CITED

ABRAHAM, A., C. A. NINAN and P. M. MATHEW. 1962. Studies on the cytology and phylogeny of the pteridophytes. VII. Observations on one hundred species of South Indian ferns. J. Indian Bot. Soc. **41:** 339–421.

ALSTON, A. H. G. and C. B. E. BONNER. 1966. Resultats des expeditions scientifiques Genevoises au Nepal en 1952 et 1954 (Partie Botanique) 5–Pteridophyta. Candollea **15:** 193–220.

BEDDOME, R. H. 1863 -1864 (1865?). The ferns of Southern India. Gantz Bros., Madras.

BIR, S. S. 1965. Chromosome numbers in some ferns from Kodaikanal, South India. Caryologia **17:** 107–115.

CLARKE, C. B. 1880. A review of the ferns of Northern India. Trans. Linn. Soc. London II, Bot., **1:** 425–611.

HOLTTUM, R. E. 1954. Flora of Malaya, vol. II. The Ferns. Gov't. Printing Office, Singapore.

————. 1968. A Revised Flora of Malaya, Vol. II. Ferns of Malaya. Gov't. Printing Office, Singapore.

MANTON, I. and W. A. SLEDGE. 1954. Observation on the cytology and taxonomy of the pteridophytic flora of ceylon. Phil. Trans. Roy. Soc. London, B, **238:** 127–185.

MEHRA, P. N. and S. C. VERMA. 1954. The cytology of some Athyrium species from Northern India. Ann. Bot., n.s., **21:** 455–459.

SLEDGE, W. A. 1962. The Athyrioid ferns of Ceylon. Bull. Brit. Mus. (Nat. Hist.). Bot., **2:** 277–323

NOTES AND NEWS

DALE J. HAGENAH, well known student of American pteridophytes and outstanding Michigan botanist, died on October 30, 1971. He had recently retired from his job as Senior Quality Control Engineer with the Chrysler Corportation so that he could spend full time on his study of ferns. He had also been appointed the Curator of the Herbarium at the Cranbrook Institute of Science, Bloomfield Hills, Michigan. He joined the American Fern Society in 1948 and was active in promoting its goals through his leadership of field forays and his encouragement and assistance to pteridologists here and abroad. He published five articles in the Journal over the years 1954 through 1966.

Hagenah's botanical interests were broad, but pteridology was his major effort. He not only carried out original research in botany, but also concerned himself with various public aspects of botany, such as the Michigan Botanical Club and especially the Michigan Natural Areas Council; to the latter he made many contributions. He was interested in the flora of Michigan in particular and the flora of the Upper Great Lakes in general. His work on ferns included not only innumerable field expeditions in Michigan and nearby Ontario, but many special investigations of critical problems. He will be remembered for his work on such problems as the distribution of the Hart's-tongue Fern, the inter-relationships of the Fragile Ferns, and hybridization in the Woodferns. At the time of his death he had become deeply interested in the Bog Clubmosses of the group of *Lycopodium inundatum.*

A more extensive biography of Dale Hagenah is being published by S. A. Cain and W. H. Wagner, Jr. (Michigan Botanist **11:** 60–66. March 1972) containing his complete bibliography.—*W. H. Wagner, Jr., Department of Botany, University of Michigan, Ann Arbor, MI 48104.*

SHORTER NOTES

LYCOPODIUM APPRESSUM ADVENTIVE IN THE BLUE RIDGE OF GEORGIA.—Two colonies of this plant have been found about 25 meters apart in the abandoned roadbed of a railroad in the southern part of Rabun County, Georgia. The locality is in a cut through granitic rocks. The ditches and the roadbed are moist to wet from seepage from the rocks. The fern could not have grown there prior to the cut's being made, and is almost certainly of recent introduction. The two colonies measure about 40–45 cm wide and 100 cm long. Vouchers for this new station are *Funderburk* on 21 July 1971 and *W. H. Duncan 23648* on 27 Aug. 1971 (both GA). *Lygodium palmatum* (Bernh.) Swartz, also obviously a recent adventive, grows abundantly in the cut, and was reported there by Snyder (Amer. Fern J. **45:** 104–105. 1955).

Lycopodium appressum is known to occur in the Blue Ridge of North Carolina, and is cited from Clay, Macon, and Jackson Counties by Radford et al. in the "Manual of the Vascular Flora of the Carolinas." We do not know whether or not the plants there are recently adventive. This species was adventive after 1918 in Clarke County, Georgia, according to Duncan (Amer. Fern J. **40:** 170. 1950), where it occurred at the margin of a water reservoir. A raised water level has recently eliminated the colony. It also occurs about 30 km SSE of the Rabun County station in a previously unreported locality, a natural "sphagnous depression" in Stephens County, Georgia, at the edge of the Piedmont Province. The voucher for this station is Camp Mikell, *H. W. Bookout, Jr. 48* on 22 July 1957 (GA).—*Wilbur H. Duncan and David Funderburk, University of Georgia, Athens, GA 30601 and Fernbank Science Center, Atlanta, GA 30307.*

SOME OVERLOOKED COMBINATIONS FOR EASTERN NORTH AMERICAN FERNS.—Several new combinations were validly published in the first edition of Amos Eaton's "Manual of the Botany of North America" (1817), but they have been universally overlooked, in the "Index Filicum," in Broun's "Index to North American Ferns," and elsewhere. The only combination of importance is *Athyrium asplenioides* (Michx.) A. Eaton, which is the correct authority for those who recognize the Southern Lady Fern as a distinct species. At present the authority is cited as *A. asplenioides* (Michx.) Desv., but Desvaux's combination was made in 1827, ten years later than that of Eaton. The combinations are:

Athyrium asplenioides (Michx.) A. Eaton, Man. Bot. No. Amer. 122. 1817.
Nephrodium asplenioides Michx.

Athyrium bulbiferum (L.) A. Eaton, loc. cit.
Polypodium bulbiferum L.

Athyrium rufidulum (Michx.) A. Eaton, loc. cit.
Nephrodium rufidulum Michx.

Athyrium tenue (Michx.) A. Eaton, loc. cit.
Nephrodium tenue Michx.

C. V. Morton, U. S. National Museum, Washington, DC, 20560.

REVIEW

"A FLORA OF TROPICAL FLORIDA," by Robert W. Long and Olga Lakela. 1–962 pp. 1971. Published by the University of Miami Press, Coral Gables, FL $29.50.—This new major flora covers the southernmost tip of Florida, mostly in Collier, Dade, and Monroe Counties, which include the Everglades and the Florida Keys. This area has received national attention by conservationists because of the inroads being made by man and the consequent danger of extinction to the flora and fauna. This fine volume points up the large number of species of vascular plants that occur in the United States only in this area, among them many endemics that are found only there. All the families are illustrated by fine and accurate line drawings. The families were divided by the authors, and the pteridophytes were treated by Dr. Lakela, whose interests were transferred a few years ago from the northernmost United States in Minnesota to the southernmost. The ferns are not the most interesting component of the flora, even though many of them occur only here in the United States. They are the northernmost outliers of the West Indian flora. Almost all of them occur in Cuba or the Bahamas, and some of them are probably rather recent introductions, for they have been found in Florida only in this century and in some cases only in the last few years. Many of these are rare and some perhaps known only from single localities. It has not been proved, but it seems possible that spores (or even whole plants) may have arrived by way of hurricanes. A few species like *Pteris tripartita* and *Thelypteris torresiana* [until recently often known as *Dryopteris setigera* or *Thelypteris uliginosa*] are definitely introduced, although some people have a hard time believing that, for they are now common and have spread into even relatively undisturbed areas. The fern treatment follows Copeland closely in the families and genera recognized. As usual in keys, a key to the genera would work better than the generalized-type family key presented, which will not really work with exceptional genera or species. The family Davalliaceae appears twice in the key although there is only one genus [*Nephrolepis*] of the family treated, and this is taken care of in one arm of the key; the other arm leads to nothing. There are some errors in the authorities, such as attributing the combination *Thelypteris sclerophylla* to Kunze when it is actually "(Poeppig ex Spreng.) Morton," but these will not impair the usefulness of the work. One of the valuable sections is an account by Joseph Ewan of the early botanical collectors in the area. One feature that does not appeal to me are five drawings of collectors (Curtiss, Garber, Small, Safford, and Killip) that are not very flattering and do not resemble the subjects very much.—*C.V.M.*

Suggestions to Contributors

Manuscripts should follow recent Journal style and should be prepared in accordance with the second edition of the AIBS (1964) *Style Manual for Biological Journals*. For major articles with more than one literature reference, use the "name and year" system for bibliographic references and the American Standards Association list of bibliographic abbreviations (AIBS, 1964, pp. 74-78), which may be supplemented by the list of Schwarten and Rickett (1958), or by those in the comprehensive "Botanico-Periodicum-Huntianum" (Lawrence et al., 1968). Put a single reference in a footnote or in the text. For shorter notes and reviews, put all references in parentheses in the text. Abbreviations of the names of herbaria should follow the list of Lanjouw and Stafleu (1964).

Art work must be "camera ready"; paste-ups are not permitted in tone copy (photographs), but if carefully done are acceptable in line copy (drawings). Scales should be included on figures and plates, rather than indicating magnification in legends.

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Reprints should be ordered when galley proof is returned to the editor. An order blank will be included with the galley proof.

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LITERATURE CITED

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES, Committee on Form and Style of the Conference of Biological Editors. 1964. Style Manual for Biological Journals, ed. 2. Washington, D. C. x + 117 pp.

LANJOUW, J. and F. A. STAFLEU. 1964. Index Herbariorum. I. The Herbaria of the World, ed. 5. Reg. Veg. 31: 1-251.

LAWRENCE, G. H. M. et al. 1968. Botanico-Periodicum-Huntianum. Hunt Botanical Library, Pittsburgh. 1063 pp.

SCHWARTEN, LAZELLA, and H. W. RICKETT. 1958. Abbreviations of titles of serials cited by botanists. Bull. Torr. Bot. Club **85:** 277-300. See also the supplement in Bull. Torr. Bot. Club **88:** 1-10. 1961.

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Volume 62

Number 2

April–June, 1972

QUARTERLY JOURNAL OF THE AMERICAN FERN SOCIETY

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The "American Fern Journal" is an illustrated quarterly devoted to the general study of ferns. It is owned by the American Fern Society, and published at 3200 Falls Cliff Rd., Baltimore, Md. 21211. Second-class postage paid at Baltimore.

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Changes of address, applications for membership, subscriptions, orders for back numbers should be addressed to the Treasurer.

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Solanopteris brunei, a Little-known Fern Epiphyte with Dimorphic Stems[1]

W. H. WAGNER, JR.*

Although the stems of ferns tend to be of only one basic type—the rhizome—there are a number of striking variations known, both in internal structure and in gross morphology. In size alone, rhizomes vary from the massive upright trunks of certain tree ferns down to the almost filiform structures of many filmy ferns. Very few species of ferns have evolved dimorphic stems showing "division of labor." Some do have differentiation into short shoots and long shoots, i.e., those with short internodes and those with long internodes. Where dimorphism occurs, it is associated functionally, as a rule, either with vegetative propagation or with storage. For example, the Ostrich Fern, *Matteuccia,* has compact, upright, frond-bearing stems and elongate, horizontal stems. The latter enable the plant to form large colonies or clones. Similar, but even narrower and more specialized "stolons" are found in some species of sword ferns, *Nephrolepis.*

Most examples of drastically modified stems, such as the strongly flattened rhizomes of *Myrmecophila* and *Lecanopteris* or the tuber-like bodies of *Nephrolepis, Polypodium,* and the plants to be described below, are epiphytic. Furthermore, they seem to be associated with storage and possibly even symbiotic relationships with ants. Indeed, except for those ferns which have obviously solid "tubers," practically all of these plants have been referred to as "ant-plants" or "myrmecophytes," whether or not any obligatory relationships with ants have been observed or experimentally demonstrated.

The plant to be described in this article is a little-known epiphyte with dimorphic stems (*Fig. 1*): ordinary polypodioid rhizomes and drastically modified, "potato-like" hollow tubers. Hagemann (1969, fig. 1) has recently illustrated and described the structure of these tubers in some detail, but he did not concern himself with the broader comparisons of the plant in respect to its other peculiarities and taxonomic relationships. In our investigations of *Solanopteris* we have discovered a number of distinctive characters which are described here for the first time.

The occasion for our study was the discovery in February, 1966, of a fine colony of *Solanopteris* in Costa Rica during a class in tropical epiphytes presented by the Organization for Tropical Studies. A large colony was found growing on a fallen bough of a tree in a deep rain-forest. We searched for the species again in July, 1967, but without success. The forest had been cut down and the original colony destroyed. Since our original find, no one seems to have encountered this plant in

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[1] Research conducted under National Science Foundation Grant GB 30918X, the Evolutionary Characters of Ferns. I am indebted to the Organization for Tropical Studies for the opportunity to study the plant discussed here, and to the following individuals for their various contributions: Patricia Ayers, Caloway Dodson, W. R. Hagemann, Daniel H. Janzen, D. B. Lellinger, and Job Kuijt. Mme. Tardieu-Blot, of the Muséum National d'Histoire Naturelle, Paris, kindly sent a fragment of the type collection for our study.

Fig. 1. Living plant of *S. brunei* showing fertile fronds, unmodified rhizomes, and tubers. Costa Rica, 1966. Photo by Job Kuijt.

Costa Rica, despite extensive explorations by many people. Therefore we believe that this fern is probably a great rarity, although we admit that the lack of collections may be due to its habitat.

Until Dr. Hagemann's recent publication on the tuber-like structures of this fern, little was known about it, even its generic disposition. The plant was described by Wercklé as *Polypodium* (?) *brunei* and so published by Christ. All Christ saw, however, were the tubers he received from Wercklé. For some reason, Wercklé sent no leaves or unmodified rhizomes, although he reported that the leaves were simple and belonged to *Polypodium*. Christ's description, consequently, is very vague, but sufficient to place the specimen we found. This identification was confirmed by matching our specimen with a tuber from the type collection.

The purpose of this report is to give a somewhat detailed description of this species and to place it taxonomically. Although it is unquestionably related to *S. bifrons* (Hooker) Copel., the broader taxonomic relationships of these two species are still uncertain, partly because of the scanty knowledge of the detailed characteristics of the Polypodiaceae.

The genus *Solanopteris* is based upon *Polypodium bifrons* Hooker (Copeland, 1951, pp. 75, 128). The type of *P. bifrons* is a specimen collected near Archidoña, Ecuador (*Jameson 789,* K, fragm US), found on a tree along a river. To this genus must be added:

Solanopteris brunei (Wercklé in Christ) Wagner, comb. nov.

Polypodium (?) *brunei* Wercklé in Christ, Bull. Soc. Bot. Genève, II, **1:** 221. 1909. Type: Carrillo, Prov. Limón, Costa Rica, *Wercklé* (P, fragm MICH).

Climbing epiphytic fern occurring in dense masses (*Fig. 1*) more or less intermixed with other epiphytes on branches of trees in rich forests mostly below 1000 m altitude. Leaves arising between conspicuous, hairy, tuber-like modified stems in which ants and other insects are usually found.

Rhizomes (*Fig. 2*) long-creeping, 1.5–2.5 mm in diam, commonly covered with a white, powdery material upon drying. Leaves 1–3, clustered near the tips of short, lateral shoots borne 1–4 cm distant along the creeping rhizomes; roots scattered, solitary, or clustered. Rhizome apices and young parts of the rhizomes covered with promptly deciduous, golden setae 1–3 mm long and more persistent, round, peltate scales 1 mm in diam. Tuberous rhizomes hollow, produced laterally on short shoots, brown to purplish-brown, 1.5–3 cm in diam, containing a central cavity plus several parietal cavities, these lined with roots originating around the ventral opening. Tuber wall 1.5–3 mm thick, invested with deciduous, golden, peltate-based setae 2–5 mm long and persistent, overlapping, brown-centered, round, peltate scales 0.1–0.3 mm in diam. Leaves dimorphic, bright green, drying brown, chartaceous to subcoriaceous, simple with entire or undulate margins, nearly sessile, the petioles very short with laminar wings decurrent to within 0.5–5 mm of the slightly swollen articulation. Fallen fronds leaving a raised, round scar approximately 1 mm across. Major lateral veins usually subopposite, visible on the adaxial blade surface in dried material, the vein pairs 0.3–0.9 mm distant. Ultimate veins finely reticulate with numerous included free veinlets, these usually with 1–4 short branches (*Fig. 3C, D*). Sterile leaves obovate to oblanceolate with usually broadly rounded apex and entire margin, 1.5–11.0 cm long, 1–2 cm wide (*Fig. 3C*). Fertile leaves linear-lanceolate, 7–25 cm long, 0.4–1.5 cm wide, with

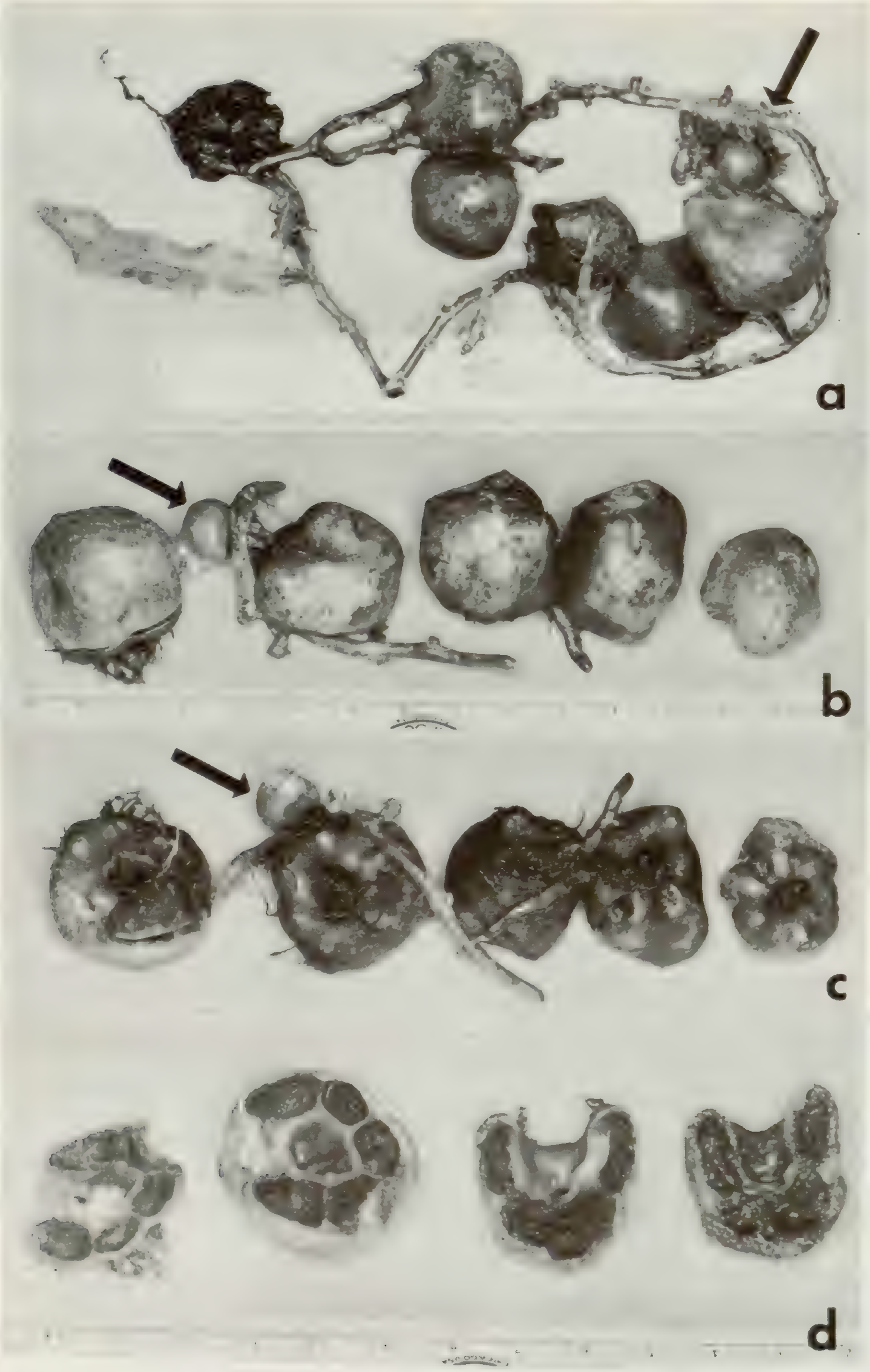

Fig. 2. Stem system of *S. brunei* showing extreme dimorphism. Arrows point to young tubers. Fig. 2A. Stem system with leaf attached. Fig. 2B. Top view of representative tubers. Fig. 2C. Same specimens turned over to show opening. Fig. 2D. Sectioned tubers. At left, sectioned transversely near top to show chambers around central cavity; at right, sectioned longitudinally. Photo by T. L. Mellichamp.

attenuate apex and more or less undulate margins (*Fig. 3D–F*); sinuses, if present, opposite the sori. Sori medial, orange-brown at maturity, subcircular to elliptical, parallel to the midrib, 2–5 mm long, 1–3 mm wide, densely paraphysate, the sporangia obscured, the paraphyses up to 1 mm long, with swollen, flattened, 6(5–9)-celled tips, the medial cells elbow-shaped (*Fig. 5*). Spores spinulose.

Additional specimens examined:

COSTA RICA: Cartago: Pejivalle, *Lankester 810* (US). **Cartago Limón:** About half way between Turrialba and Siquirres, ca 300 m, *Wagner* in 1966 (MICH). **Guanacaste:** El Arenal, 485–600 m. *Standley & Valerio 45173, 45195* (both US). **PANAMÁ: Coclé:** Region N of El Valle de Anton, 1000 m, *Allen 2880, 2899* (both US). **Panamá:** 10 mi S beyond Goofy Lake in Cerro Azul, *Correa & Dressler 176* (MICH, US). **COLOMBIA: Nariño:** 80 km E of Tumaco, Carretera past Tumaco, 150 m, *Hagemann 18926* (MICH).

This fern is evidently more closely related to *S. bifrons* than to any other known species. Hagemann (1969)[2] concluded that the tubers of *S. bifrons* and *S. brunei* have the same basic structure (with some conspicuous differences) and that they are modified lateral branches of the rhizome. The tuber surfaces usually bear eight low protuberances (*Fig. 2C*), four dorsally, which are homologous to leaf bases, and four ventrally, which correspond to lateral shoots. (Occasionally a single, more or less abortive leaf may be present on the dorsal side of the tuber.) The pith inside the vascular cyclinder is destroyed early in development, and the central cavity (*Fig. 2D*) then appears as an opening on the ventral side of the tuber. A network of roots originates around the ventral opening and grows into the cavities, appressed to their walls.

Our present geographical knowledge of *Solanopteris* is very limited. The paucity of collections, particularly of *S. brunei,* must mean that these ferns either are very rare and sporadic, or that they occur normally so high in the forest canopy that they are rarely observed or collected. *Solanopteris bifrons* is known from Colombia to Peru. *Solanopteris brunei* is best known from Costa Rica and Panamá; Hagemann's recent discovery of it in Colombia is the first record for South America.

These two species of *Solanopteris* can be distinguished by the following key:

Sterile blades entire or slightly undulate, chartaceous to subcoriaceous, rounded at the apex; venation complex, the areoles 1 3 mm long; fertile blades broad, the sori extending up to 1 mm of the margin, the marginal sinuses, if any, opposite the sori; soral paraphyses with 6(5–9)-celled tips, strongly flattened at the apex; tubers with peltate scales and brown at maturity (Costa Rica to Colombia). .....*S. brunei*

Sterile blades grossly toothed, the teeth 4–7 mm long, ca 5 mm distant, herbaceous, acute at the apex; venation complex, the areoles 4 8 mm long; fertile blades narrow, the sori extending to the margin, the marginal sinuses between the sori; soral paraphyses with 2 5-celled tips, slightly flattened at the apex; tubers becoming glabrous and white at maturity (Colombia to Peru). .....*S. bifrons*

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[2] Dr. Hagemann is currently studying yet another species of *Solanopteris* from Peru which has coenosori and the fronds borne on the tubers themselves. Whether or not his material is conspecific with *Polypodium tuberosum* Maxon (Amer. Fern J. **33:** 135. 1943), from near La Chonta, Ecuador, remains to be seen.

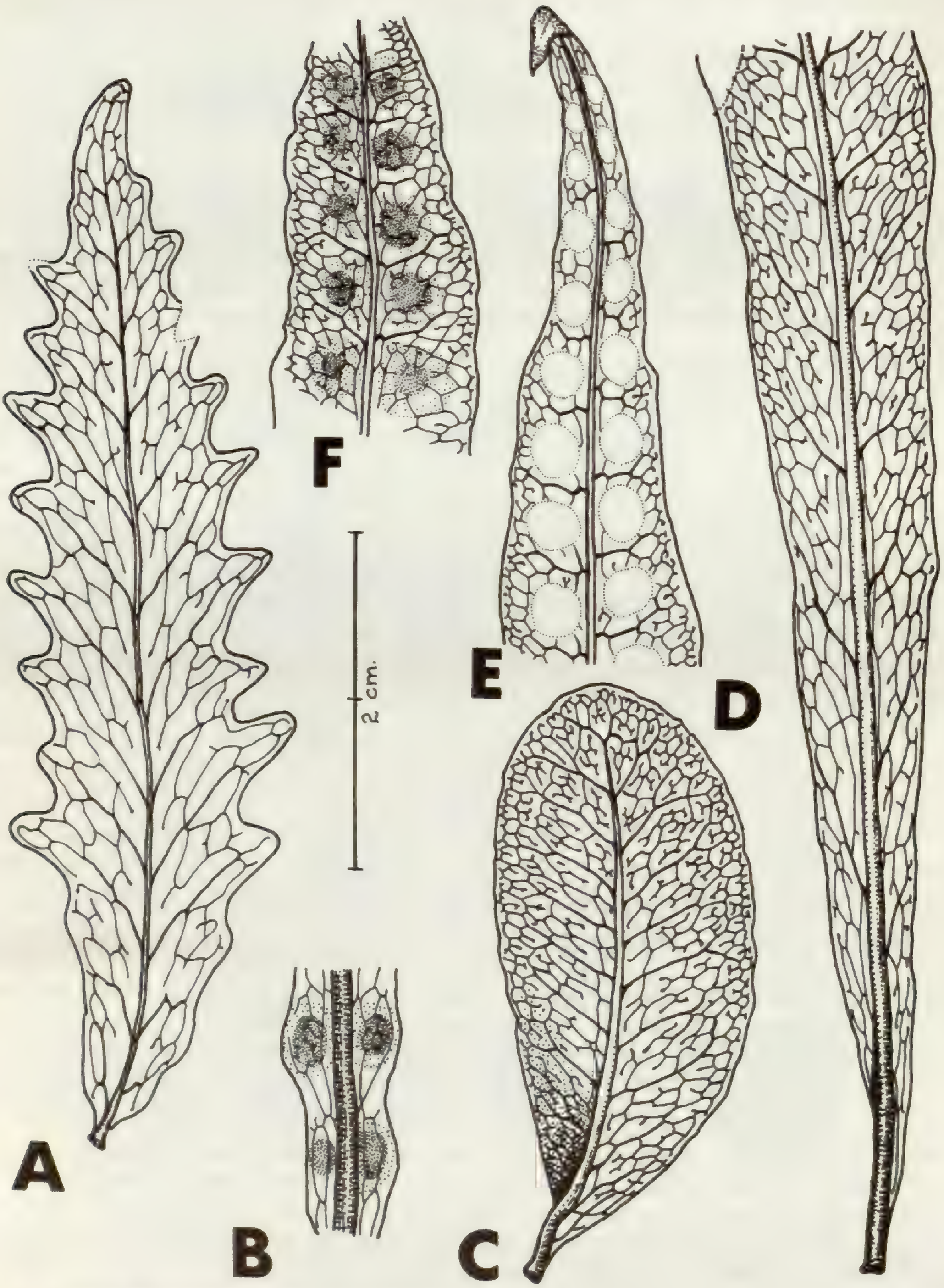

Fig. 3. Venation patterns of *Solanopteris*. Fig. 3A. *S. bifrons*, sterile leaf; Colombia, Klug 1838 (MICH). Fig. 3B. Same, portion of fertile leaf. Fig. 3C. *S. brunei*, sterile leaf, Panamá, Allen 2880 (US). Fig. 3D. *S. brunei*, base of fertile leaf, Costa Rica, Wagner (MICH). Fig. 3E. Same, tip of fertile leaf. Fig. 3F. Same, portion of leaf with sori removed to show fertile veins; the dark stippling represents receptacular area.

GENERIC RELATIONSHIPS

Our knowledge of generic relationships among the Polypodiaceae is still imperfect, especially with respect to *Microgramma* and *Pleopeltis*, which are the genera most closely related to *Solanopteris*. Copeland (1951), in writing of *S. bifrons* alone, stated that *Solanopteris* has

> more resemblance to *Microgramma* than to anything else, and this may be its affinity, but the rather fleshy, herbaceous texture, and the laxly and irregularly anastomosing veins, and the paucity of included veinlets make it seem unreasonable to include it in that genus. The tubers are remarkable; but I would not regard them as by themselves justifying generic distinction for the species, no more than do those of *Nephrolepis cordifolia*.

Standing alone, *S. bifrons* might be in question as constituting a genus. However, the presence of at least one strongly divergent additional species, but one which shares its salient characteristics, fortifies the conclusion that *Solanopteris* warrants recognition as a separate genus. In spite of Copeland's comments, the tubers are also strong justification for generic separation. Hagemann's studies reveal that they are remarkably complex, highly specialized structures.

Another character supporting generic separation is the complex, reticulate venation pattern with numerous, irregularly oriented, free included veinlets—anaxetoid venation, as illustrated by Dickason (1946, fig. 20). A few venation patterns are shown for comparison in *Fig. 4*. The veins of *Campyloneurum, Pessopteris, Phlebodium,* and *Polypodium* (*Fig. 4A, B, E, G*) are easily separated from those of *Solanopteris*. But the patterns of the two species of *Microgramma* and of *Microsorium* (*Fig. 4C, D, F*) are in some ways rather similar to those of *Solanopteris,* the *Microsorium* being somewhat intermediate between the other two genera. Evaluation of venation as a generic character is difficult, for within obviously related groups the variation of patterns may be extreme, as illustrated by Tindale (1960) and de la Sota (1960, 1966).

The other characters supporting separation are the peculiar soral paraphyses, which form a dense mat of uniseriate hairs with dilated apices (*Fig. 5*), the receptacular area that is served by a complex system of veins (*Fig. 2B, F*), and the spores, which are covered with narrow spinules.

That these two species, in spite of their common properties, have become so thoroughly differentiated from one another, suggests that they belong to a common lineage, the ancestor of which separated long ago from other polypodioids. *Solanopteris* is surely distinct from *Microgramma* and *Pleopeltis,* both of which lack the tubers, the specialized soral paraphyses, and the spiny spores of *Solanopteris*. In addition, *Microgramma* has simpler receptacular venation.

ECOLOGICAL RELATIONSHIPS

The most intriguing biological question concerning *Solanopteris* has to do with the function of its tubers. It seems difficult indeed to imagine that such specialized structures do not have some definite functional role. One may suggest that these organs are functionally related to storage tubers like those of certain sword ferns or of occasional populations of polypodies (e.g., *Polypodium polypodioides* and

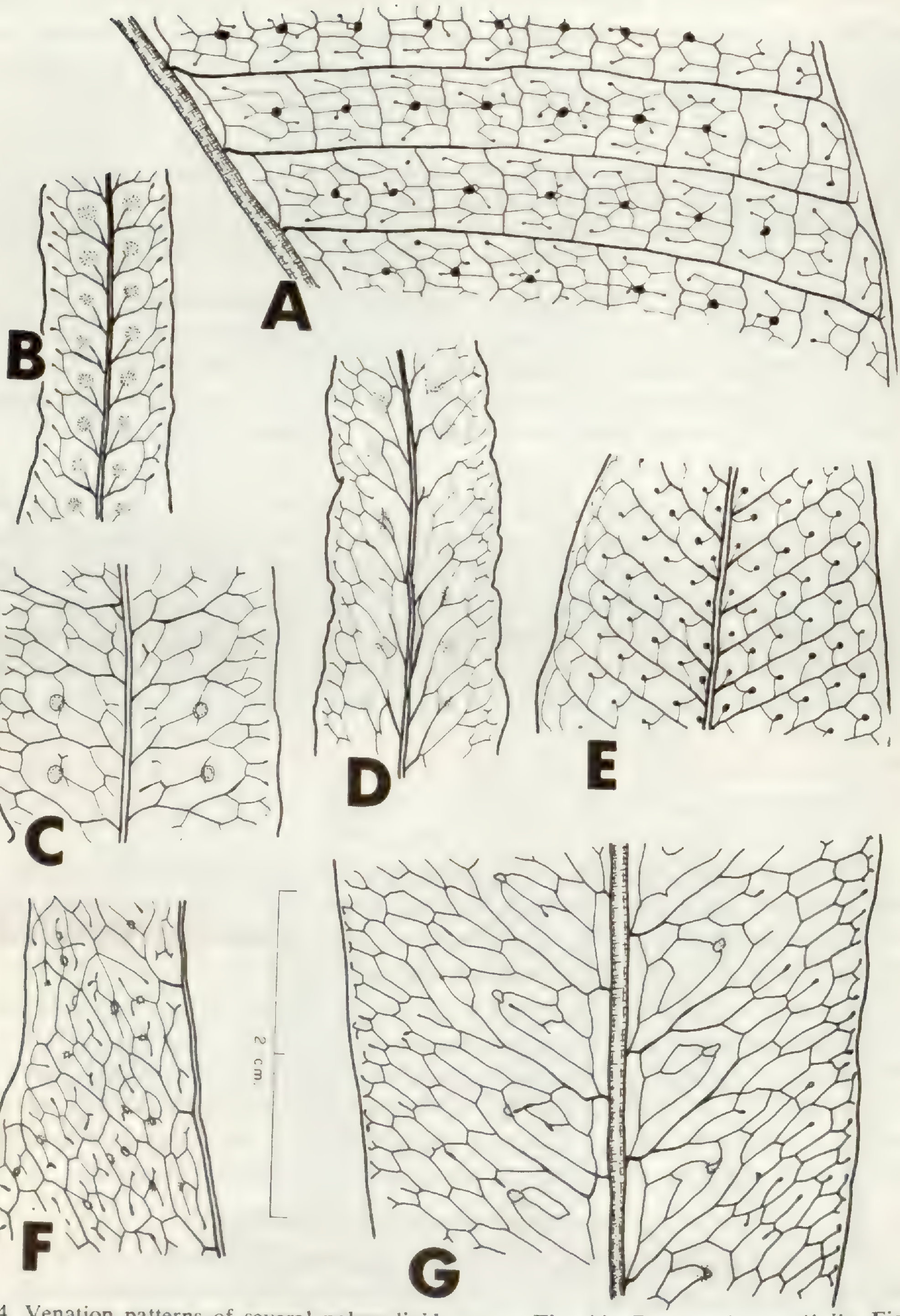

Fig. 4. Venation patterns of several polypodioid genera. Fig. 4A. *Pessopteris crassifolia*. Fig. 4B. *Polypodium* sp. Fig. 4C. *Microgramma lycopodioides*. Fig. 4D. *Microgramma heterophylla*. Fig. 4E. *Campyloneurum phyllitidis*. Fig. 4F. *Microsorium punctatum*. Fig. 4G. *Phlebodium aureum*.

Pleopeltis percussa in Costa Rica). But what physiological adaptation is involved that could bring about selection for the remarkably distinct tubers of *Solanopteris*?

Parallelisms or convergences in rhizome modification are known in certain Old World polypodies which are usually regarded as ant plants (myrmecophytes). They are presumed to be specialized for symbiotic associations with the ants that regularly inhabit their stems, and are divided into two types. The "Myrmecophila" type (e.g., *M. sinuosa* (Wall. ex Hook.) Christ ex Nakai and its relatives) is chiefly Malesian—Polynesian, and has a scaly, somewhat swollen rhizome containing chambers; the "Lecanopteris" type (e.g., *L. carnosa* (Reinw.) Blume) ranges from Sumatra and the Moluccas to the Philippines, and has a naked, extremely flattened, crustose rhizome which looks like a huge fungus sclerotium. Both types have received much attention and speculation from botanical writers because of their ant-filled rhizomes. I do not believe that *Solanopteris* is related to either of these genera, or that the two genera are necessarily related to one another.

Christ (1910, p. 289) based his statements on tuber function in *Solanopteris* on the work of Senn (1910) and Ule (1906). He believed the tubers of *S. brunei* were stems modified to hold water, whereas those of *S. bifrons* were leaves transformed for the same purpose. However, he was so impressed by their resemblances that he also suggested that they might ultimately be shown to be the same (Christ, 1910, p. 98), and Hagemann (1969) concluded that this is true. Bower (1923, pp. 43–44) compared the function of the tubers of both species of *Solanopteris* with that of the similarly specialized leaves of *Dischidia* (Asclepiadaceae), which also have cavities penetrated by roots. Bower's illustration, which is taken from Ule, does suggest *Dischidia,* but is in some ways misleading. Plants of *Dischidia* with which I am familiar show definitely pendent sacs (modified leaves), and there is clearly a more or less exposed opening at the upper end through which the roots enter. In my specimens of *Solanopteris*, the hollow bodies were apparently appressed to the substrate, opened downward, and are hardly what one would expect if the organs were truly water catchers. In *Fig. 2*, one of the tubers has been twisted upward to reveal the opening. Unfortunately, we do not know what the actual orientation of the plants is. If, for example, the clump of plants faces outward or downward, then the tuber orifices would be in position to collect water.

At the time I collected *S. brunei* I had the definite impression that there was a strong ant relationship. Indeed, I became uncomfortably covered with these crawling insects when I attempted to lift off pieces of the plant from the mass of epiphytes in which it was growing. In a letter to W. R. Maxon, dated December 10, 1949, Paul Allen wrote that:

> on the under side of these [spherical bodies] are openings into the hollow interior which [are] invariably inhabited by colonies of a small, but exceedingly bellicose species of ant. These make themselves known on the slightest disturbance of the plant, racing at top speed over your protesting anatomy, until fortune favors them with a particularly succulent spot to clamp on to, which they do with a vengeance.

Allen also wrote in his unpublished manuscript "Orchids of Middle America"

(kindly transcribed for me by Caloway H. Dodson):

> A single large tree may support, besides orchids and hepatics, many and extremely diverse kinds of ferns and fern allies, which range from tiny species of *Trichomanes*, scarcely an inch in height, to such unlikely creations as *Polypodium brunei*, whose creeping stems develop clusters of fantastic purple, hairy tubers, harboring in their hollow interiors, militant ants and huge scale insects, the latter turret-like in form.

The reports of ants present in the tubers are not consistent. Although Allen wrote that they were "invariably inhabited" by them, the Standley and Valerio specimens are labelled "often but not always infested by ants." Lankester's specimen annotation was especially interesting: "Gall like excrescences on the rhizomes, massed or single; in section, formed of 4 cells. *No tenants found*. Hairy outside."

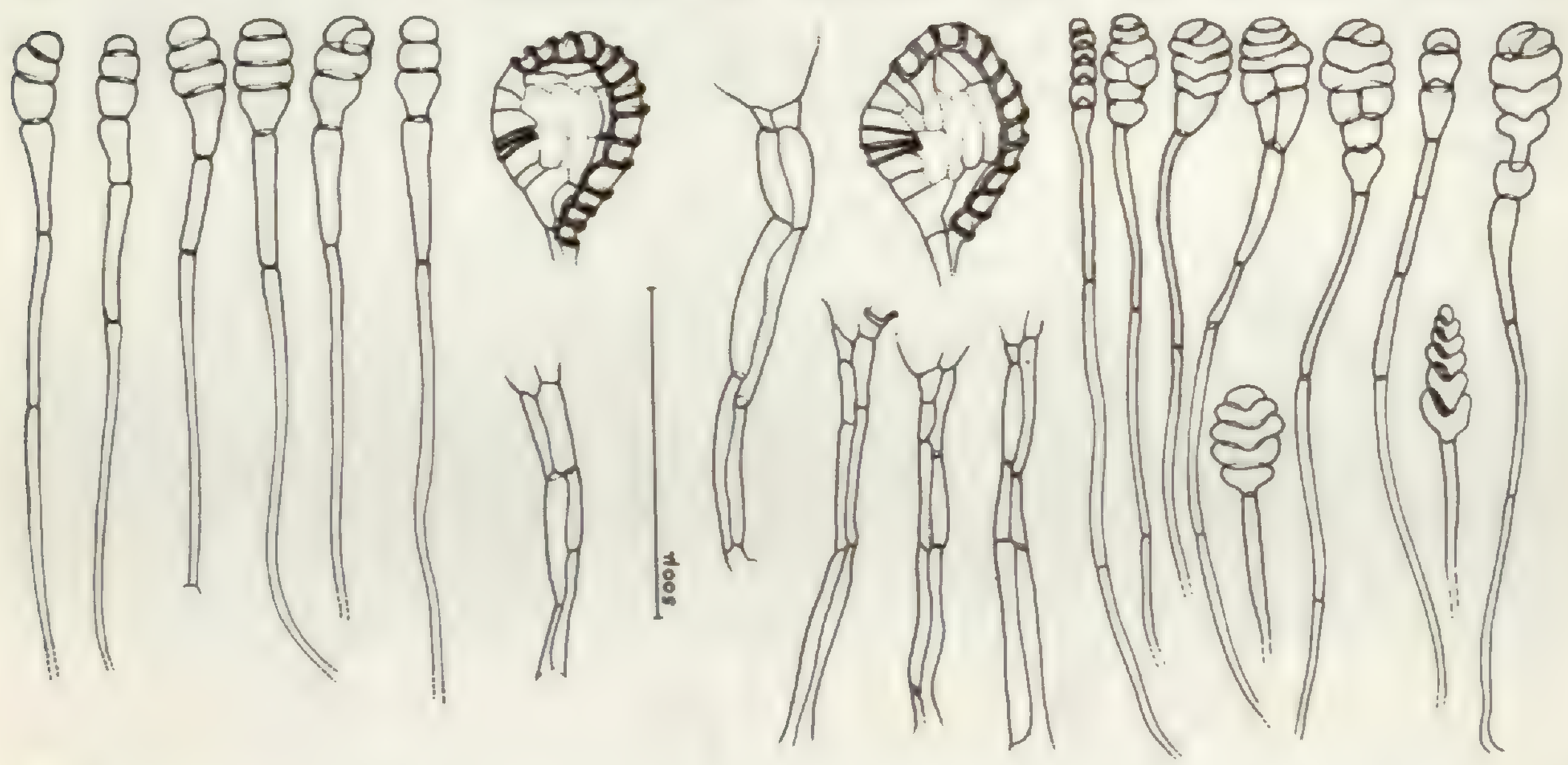

Fig. 5. Soral structures of *Solanopteris*. *S. bifrons*, Colombia, Klug 1838 (MICH) to left of scale; *S. brunei*, Costa Rica, Wagner (MICH) to right.

He apparently later added a postscript reading "*Observed later swarming with ants*." The collection of Correa and Dressler bears the notes "Fern with rhizome tubers present. Ants living in the tubers." On the contrary, in correspondence with Dr. Hagemann, I received the information that "There were a lot of plants, but I couldn't find any ant within the tubers of the fern." Hagemann also wrote (1969) that myrmecophily in these plants is probably facultative, as Maxon (1943) also implied.

I sent seven tubers of *S. brunei* to Dr. Daniel H. Janzen. He found one worker *Camponotus* sp. in one and three of the same species in another; he found no evidence that this fern is a myrmecophyte. He reported that the ants he found in the *Solanopteris* tubers commonly nest in cavities in rotting wood and, with one or two doubtful exceptions, are not involved with myrmecophytes, except as occasional facultative tenants, anywhere in the world.

The probable function of the tubers of *Solanopteris* remains unclear. More field research is needed, especially on the plants *in situ*.

LITERATURE CITED

BOWER, F. O. 1923. The Ferns (Filicales), vol. I. Cambridge Univ. Press.
CHRIST, H. 1909. Primitiae Florae Costaricensis. Filices, VI. Bull. Soc. Bot. Genève, II, 1: 216–236.
———. 1910. Die Geographie der Farne. Gustav Fischer, Jena.
COPELAND, E. B. 1947. Genera Filicum. Chronica Botanica, Waltham, Mass.
———. 1951. A new genus of ferns. Amer. Fern J. **41:** 75–76.
DICKASON, F. A. 1946. A phylogenetic study of the ferns of Burma. Ohio J. Sci. **46:** 73 108.
HAGEMANN, W. 1969. Zur Morphologie der Knolle von Polypodium bifrons Hook. und P. brunei Wercklé. Mém. Soc. Bot. France **1969:** 17–27.
MAXON, W. R. 1943. New tropical American ferns–XIV. Amer. Fern J. **33:** 133–137.
SENN, G. 1910. Die Knollen von Polypodium Brunei Wercklé. Verhandl. Naturf. Ges. Basel **21:** 115–125.
SOTA, E. R. DE LA 1960. Polypodiaceae y Grammitidaceae Argentinas. Opera Lilloana **5:** 1–229.
———. 1966. Revisión de las especies Americanas del grupo "Polypodium squamatum" L. Rev. Mus. La Plata, N.S., Bot. **10:** 69–186.
TINDALE, MARY D. 1960. Vein patterns in Microsorium scandens and its allies. Amer. Fern J. **50:** 241–245.
ULE, E. 1906. Ameisenpflanzen. Bot. Jahrb. Engler **37:** 335–352.

RECENT FERN LITERATURE

"SYSTEMATICS OF THE NEOTROPICAL SPECIES OF THELYPTERIS SECTION CYCLOSORUS" (Univ. Calif. Publ. Bot., vol. 59), by Alan R. Smith. vi + 143 pp. 1971. Published by the Univ. of California Press, Berkeley, CA 94720. $6.50.—Dr. Smith has produced a model monograph, containing morphological, cytological, phytogeographic, ecological, and nomenclatural data, on this taxonomically troublesome group. A detailed and well-illustrated account of gametophyte and sporophyte anatomy and morphology is presented, as is a table of over 60 morphological characters for all the species and varieties; the latter can be used as a multiple-entry key. A considerable number of cytological observations are synthesized into an account of the evolution of the group, and some notes on evolution in the genus as a whole are also given. The dichotomous key, I can report from personal experience, works well, although it is a trifle confusing because of improper indentation between couplets 11 and 12 and 12 and 15. Taxa requiring it are mapped or illustrated with original line drawings or sometimes photographs that are clear and helpful. The nomenclature is carefully reasoned and exceptionally well documented. The discussions accompanying the taxa are especially valuable in contrasting similar species in ways not accomplished by the dichotomous key. Dr. Smith has published his new taxa and combinations under the authority "A. Reid Smith" in order to avoid conflict with another Alan R. Smith, who is also working on pteridophytes in Great Britain. Lists of hybrids, names of uncertain status, excluded names, and representative specimens, and literature cited conclude the volume, which regrettably lacks an index—the only serious defect in an excellent piece of work—*D. B. L.*

Cytological Observations on Asplenium paucivenosum

S. S. BIR*

Asplenium paucivenosum (Ching) Bir (Bull. Bot. Surv. India **4:** 3. 1962a) was described as *Ceterach paucivenosa* by Ching in 1931 from Yunnan, a province of China adjacent to Burma. It closely resembles *A. dalhousiae* Hooker [*Ceterach dalhousiae* (Hooker) C Chr.], with which the eastern Himalayan specimens have often been considered conspecific.

In the Indian region *A. paucivenosum* is confined to the eastern part (Darjeeling Sikkim east to Assam), whereas *A. dalhousiae* is found in the western part of the Himalayas (Nepal west to Kashmir). Both of these spleenworts were placed in the genus *Ceterachopsis* by Ching (1940), which has been recognized as a subgenus of *Asplenium* by Bir (1962a; Mehra & Bir, 1964). The species of *Asplenium* subg. *Ceterachopsis* superficially resemble *Ceterach officinarum* Lam. & DC. in frond size and pinnatifid frond outline, but differ in having indusia covering the sori and in the absence of scales on the under surface of the laminae. They occur in Yunnan and the Himalayas south to Burma, and also in Ethiopia, Arizona, and northwestern Mexico.

Asplenium paucivenosum is very rare in the eastern Himalayas. It prefers well-shaded rock crevices deep in the forests in the Darjeeling district of West Bengal and Sikkim, between 2,400 and 2,700 m altitude. The chief features distinguishing *A. paucivenosum* from *A. dalhousiae* are the conspicuously hyaline and chartaceous margin of the pinna lobes, the discrete sori at maturity with well-developed, persistent indusia (which are almost the same size in both species), and the large spores (70–86μ × 54–62μ) with a very broad perispore forming a reticulate pattern of the surface folds. The fronds are 4–30 cm long and 1.5–5 cm wide, with small but distinct, scaly stipes and midribs that are scaly beneath and often wavy; the sinuses between the lobes of the laminae are rounded.

Asplenium dalhousiae, which grows in the crevices of rocks or masonry or often in the shade at the base of shrubs between 900 and 2,100 m altitude, has often confluent sori, with the indusium curling back or even deciduous at maturity, and small spores (28–45μ × 24–30μ) with a relatively narrow, folded perispore. Throughout the western Himalayas (Kulu, Simla, Nainital, and Mussoorie) *A. dalhousiae* is a diploid, with n = 36 (Bir, 1959, 1962b, 1965; Mehra & Bir, 1957).

Both tetraploid and octoploid sexual plants of *A. paucivenosum* have been found in Darjeeling and Sikkim in the eastern Himalayas (Bir, 1960; Bir in Mehra, 1961). These are easily distinguishable in the field on the basis of frond size (*Figs. 1A, 2A*). Tetraploid plants ($n = 72$ during meiosis; *Fig. 1B*), collected only at Tonglu, have small fronds. The octoploid plants ($n = 144$ during meiosis; *Fig. 2B*) grow abundantly in Senchal forest near Darjeeling and near Lachen in Sikkim. These are robust, with larger fronds, stomata, epidermal cells, and spores (*Fig. 2C, D*).

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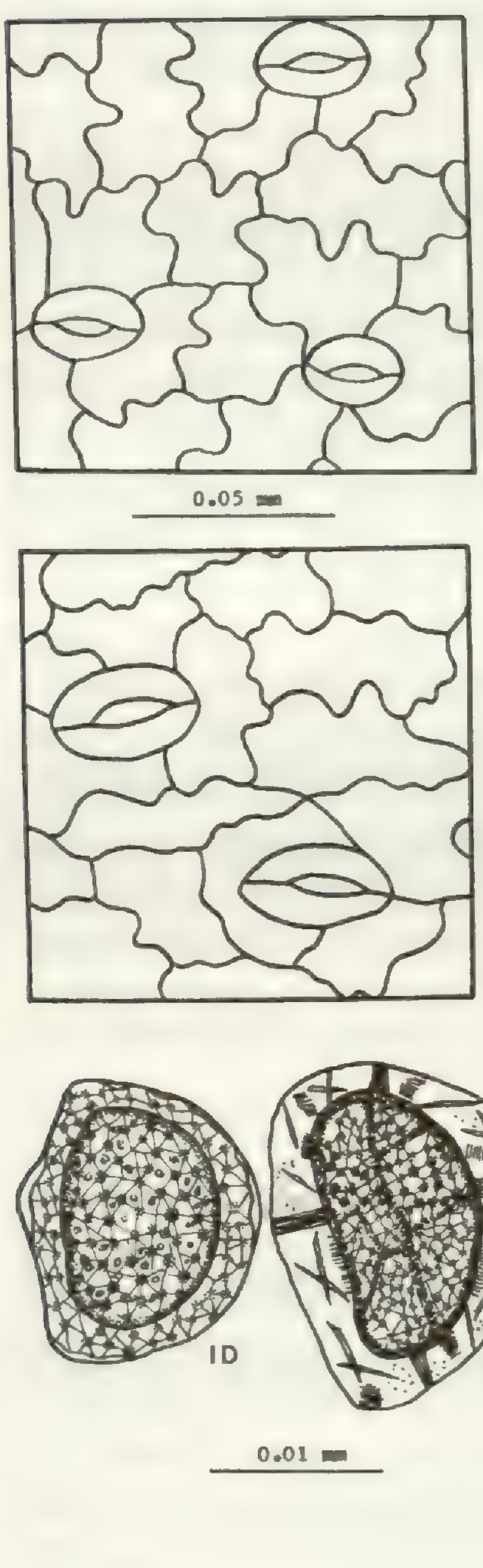

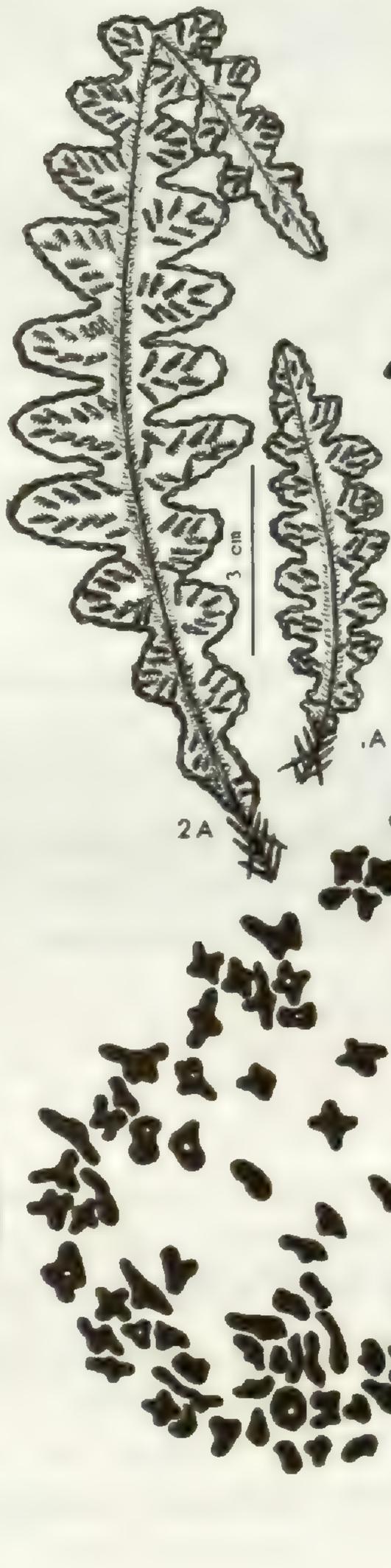

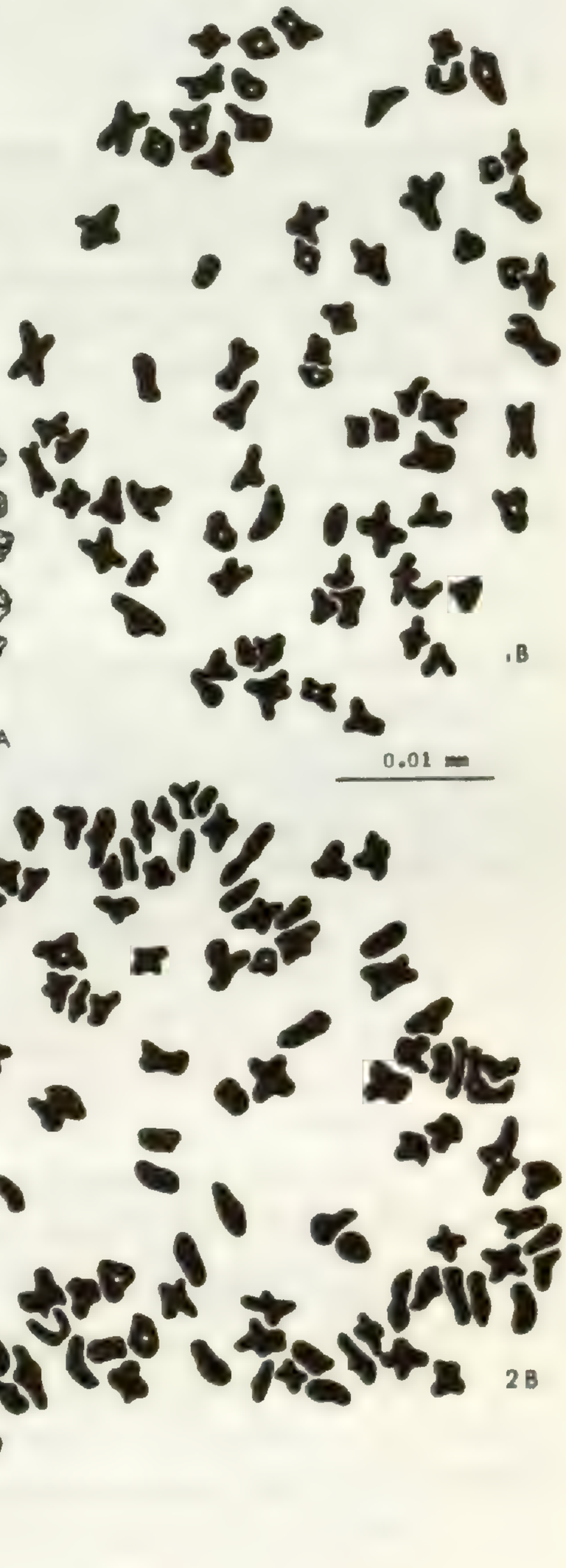

Figs. 1–2. *Asplenium paucivenosum*. Fig. 1A–D. Frond, spore mother cell, lower epidermis, and spore of *A. paucivenosum* f. *minus* ($4x = 144$). Fig. 2A–D. Frond, spore mother cell, lower epidermis, and spore of *A. paucivenosum* f. *majus* ($8x = 288$).

The cytomorphological distinctness of the two forms of *A. paucivenosum* clearly justifies their taxonomic recognition:

Asplenium paucivenosum f. minus Bir, f. nov. Fig. 1

Frondes 4–10 cm longae, 1.5–2.5 cm latae; pinnae mediales usque ad 1.5 cm longae, 0.8 cm basi latae; stomata 24–27μ longa; cellulae annuli 18–22; sporae ca 70 $\times$ 54μ, ala perisporiali fusca opaca; $2n = 4x = 144$.

HOLOTYPE: Tonglu, Darjeeling, India, 2700 m alt, *S. S. Bir* (PAN[1] 692; ISOTYPES: PAN 693–695).

Asplenium paucivenosum f. majus Bir, f. nov. Fig. 2

Frondes 20–30 cm longae, 3–5 cm latae; pinnae mediales ca 2.5 cm longae, 1.5 cm basi latae; stomata 36–39μ longa; cellulae annuli 20–24; sporae ca 86 $\times$ 62μ, ala perisporali translucente; $2n = 8x = 288$.

HOLOTYPE: Senchal Lake, Darjeeling, India, 2400 m, *S. S. Bir* (PAN 1602). PARATYPES: Lachen, northern Sikkim, 2400 m, *S. S. Bir* (PAN 1955–1959). Senchal Lake, Darjeeling, India, 2400 m, *S. S. Bir* (PAN 4762).

I am thankful to C. V. Morton and D. B. Lellinger for their helpful criticism and preparation of the Latin diagnoses.

LITERATURE CITED

BIR, S. S. 1959. Cytotaxonomic notes on some Aspleniaceae from Kulu Valley. J. Indian Bot. Soc. **38:** 528–547

————. 1960. Cytological observations on the East Himalayan members of Asplenium Linn. Curr. Sci. **29:** 445–447.

————. 1962a. Taxonomy of the Indian members of family "Aspleniaceae." Bull. Bot. Surv. India. **4:** 1–16

————. 1962b. Cytological observation on some ferns from Simla (Western Himalayas). Curr. Sci. **31:** 248–250.

————. 1965. Cytomorphological studies in the families Aspleniaceae, Blechnaceae and Vittariaceae. Ph.D. Thesis, Panjab University, Chandigarh, India.

CHING, R. C. 1940. The studies of Chinese ferns–XXX. Bull. Fan Mem. Inst. Biol., Bot. **10:** 1–22.

MEHRA, P. N. 1961. Chromosome numbers in Himalayan ferns. Res. Bull. Panjab Univ., N.S., Sci. **12:** 139–164.

————, and S. S. BIR. 1957. Cytology of some Indian species of Asplenium L. Curr. Sci. **26:** 151–152.

————, and S. S. BIR. 1964. Pteridophytic flora of Darjeeling and Sikkim Himalayas. Res. Bull. Panjab Univ., N.S., Sci. **15:** 69–182.

[1] Abbreviation of the Panjab University Herbarium, Chandigarh, India.

Some Interesting Fern Finds and Records in Northern Illinois[1]

DONALD McFALL* and MICHAEL JONES**

Since the publication in 1967 of Mohlenbrock's "The Illustrated Flora of Illinois. Ferns," a number of new records have been discovered, not only by Mohlenbrock and his co-workers, but by others as well. We present here some of the results of our own field studies in the upper Rock River Valley. Included are new range extensions for *Botrychium* and *Ophioglossum*. Two of the records are apparently first records for the state.

On June 15, 1970, we discovered an unusual area in Rock Cut State Park, northeast of Rockford, Winnebago County, where we collected six species of the family Ophioglossaceae in an area of only half an acre. Two of these, the Daisy-leaf Grapefern, *Botrychium matricariifolium* A. Braun, and the Dwarf Grapefern, *B. simplex* E. Hitchc., proved to be previously unrecorded anywhere in Illinois; and another, *Ophioglossum vulgatum* L., was unknown in the north-central part of the state.

Botrychium matricariifolium is rare at the site, growing on the sparsely vegetated floor of a young, second-growth, upland Sugar Maple woods, a habitat rare in northern Illinois. *Solanum nigrum* was the only constant, immediate associate noted. The nearest previously reported stations of this Grapefern are 140 miles eastward in southwestern Michigan (Hagenah, 1966) and 180 miles to the north, near Green Bay, Wisconsin (Tryon et al., 1940, p. 103).

Botrychium simplex (closest to var. *tenebrosum* (A. A. Eat.) Clausen) is found both in the Maple woods and in an adjoining thicket which appears to have been dry prairie in the recent past, but which has now grown up to very small trees of Slippery Elm. We observed no constant associate for *Botrychium simplex*, except for the Elm. Spot checks have indicated that this Grapefern is common at the site, although it is very inconspicuous. The Dwarf Grapefern is known in northwestern Indiana approximately 115 miles from the Winnebago County station (Deam, 1940, p. 38) and in Wisconsin near Sheboygan, about 125 miles north of the site (Tryon et al., 1940, p. 101).

Adder's-tongue, *Ophioglossum vulgatum*, is abundant in the thicket in association with *Botrychium simplex*. Here it tends to form colonies, often in the middle of large patches of Pussytoes (*Antennaria* sp.). The associates of Adder's-tongue at this site include *Botrychium dissectum* f. *dissectum* and f. *obliquum*, *B. multifidum*, *Asplenium platyneuron*, *Ulmus rubra*, *Liparis loeselii*, and *L. liliifolia*. The variety of Adder's-tongue represented is the northern one, *O. vulgatum* var. *pseu-*

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[1] We wish to thank Dr. Warren H. Wagner, Jr., of the University of Michigan, Ann Arbor; Dr. Richard L. Hauke, of the University of Rhode Island, Kingston; and especially Dr. Robert A. Evers, of the Illinois Natural History Survey for their verification of the identifications. We also thank William Shepherd for reviewing the manuscript.

dopodum (Blake) Farw. This new record has been plotted on a range map published by Wagner (1971). It is the second report of this variety in Illinois, all the other collections being the Southeastern Adder's-tongue, *O. vulgatum* var. *pycnostichum* Fern.

The finds reported here bring to 45 the total of ferns and fern allies now known from Winnebago, Ogle and Lee Counties in the upper Rock River Valley of Illinois. As our explorations continue, the area may prove to be one of the richest and most exciting parts of the state for those interested in pteridophytes.

LITERATURE CITED

DEAM, C. 1940. Flora of Indiana. Burford Printing Co., Indianapolis, Ind. 1236 pp.

HAGENAH, D. J. 1966. Notes on Michigan Pteridophytes, II. Distribution of the Ophioglossaceae. Amer. Fern J. **56:** 150–163.

MOHLENBROCK, R. H. 1967. The Illustrated Flora of Illinois. Ferns. S. Illinois Univ. Press, Carbondale, xi + 191 pp.

TRYON, R. M. JR., N. C. FASSETT, D. W. DUNLOP, and M. E. DIEMER. 1940. The Ferns and Fern Allies of Wisconsin. Dept. of Botany, Univ. of Wisconsin, Madison. v + 158 pp.

WAGNER, W. H., JR. 1971. The Southern Adder's-tongue, Ophioglossum vulgatum var. pycnostichum found for the first time in Michigan. Michigan Bot. **10:** 67-74.

RECENT FERN LITERATURE

"INDEX TO EQUISETOPHYTA. PART 1: FOSSILES. PART 2: RECENTES," by Clyde F. Reed. Part 1, 402 pp., 1971 [but not distributed until June, 1972]; part 2, 128 pp, March 30, 1971.—Dr. Reed has continued his useful series of indices of the "fern allies" with this index of the fossil and living genera and species of the horsetails, *Equisetum,* and related plants. The fossils are the most numerous, including the well-known genera *Calamites* and *Sphenophyllum,* and also a large number of doubtful genera and species. The number of names indexed in the part dealing with the living species of *Equisetum* is of the order of 1800, which is amazing considering that there are only 29 accepted species, including several hybrids. Most of the names are attributable to minor vegetative forms. Many of the living species have also been found as fossils. The work is for sale by the Reed Herbarium, 10105 Harford Road, Baltimore, MD 21234.—*C.V.M.*

Five New Species of South American Polybotrya[1]

DAVID B. LELLINGER*

Few fern genera have had less study over the years than *Polybotrya*. Fée (1845) described several species and, in a limited sense, is its only monographer. In recent years, the late Dr. A. C. Brade (1969a, b, c) described several species from Brazil, Costa Rica, and Venezuela. The Andean species, however, have scarcely been studied at all. Besides the ones described in this paper, recent exploration in Colombia (Lellinger & de la Sota, 1972) has brought several others to light, which will be described in another paper. Still others must remain undescribed for want of fertile and sufficiently mature sterile material.

Like *Maxonia*, which is similar and related to *Polybotrya* but which has indusiate sori, *Polybotrya* is a hemiepiphyte. It has a high-climbing rhizome that remains rooted in the soil, giving the plant the positional advantage of an epiphyte for spore distribution and exposure to light and the terrestrial advantage of water supplied by the soil. The spores of *Polybotrya* germinate, for the most part, on the ground. The young, thin, rhizomes bear scattered, usually juvenile, sterile fronds and creep in the soil or leaf mold until reaching a tree. (I once found a dense bed some 20 m in diameter of young *Polybotrya alfredii* fronds, near Zapote, Costa Rica. The forest had been logged recently, and I believe the additional light either caused the adult plants to produce fertile fronds and spores or influenced the success of the gametophytes and young sporophytes.) The rhizomes often increase in diameter as they grow upward on the tree trunk. Naturally, the most mature sterile fronds and the fertile fronds are borne toward the rhizome apex. Because of the variability in size and dissection of the juvenile to mature sterile fronds, it is important to trace the rhizome back to its connection with the ground and to collect both juvenile and mature sterile fronds, as well as fertile fronds, when they are available.

I have attempted to state the relationships of the new species described and illustrated below, in hopes of aiding future monographers.

Polybotrya crassirhizoma Lellinger, sp. nov. Figs. 1 and 8.

Planta hemiepiphytica; rhizoma scandens, 1–1.5 cm diam, dense et laxe paleaceum, paleis linearibus usque ad 1.5 cm longis, 0.5 mm latis, concoloribus vel plus minusve concoloribus basi bicoloribus brunneis cum marginibus pallidioribus, rufocastaneis, obscuris, marginibus erosodenticulatis, cellulis contortis; stipites 10–21(102) cm longi, 2.5–5 mm diam, straminei sulcati, basi dense paleacei, sursum parce paleacei, paleis linearibus usque ad 1.5 cm longis, 0.3 mm latis (basi 0.5 mm latis), leviter bicoloribus brunneis cum marginibus pallidioribus, marginibus dentatis; rhachides stramineae sulcatae pilosulae in sulco, parce paleaceae, paleis eis stipitum similibus praeditae; laminae steriles papyraceae vel subcoriaceae, lanceolatae, basi fere truncatae, apice acutae, 50–75 cm longae, 20–35 cm latae apice pinnatifidae, pinnatae, pinnis 14–18 paribus alternis vel suboppositis, inferiori-

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[1] Partial cost of publication borne by the Smithsonian Institution. The services of Miss Alice Tangerini, who prepared Figs. 8–12, are gratefully acknowledged.

Fig. 1. Holotype of *Polybotrya crassirhizoma*, Schunke 268 (US). Fig. 2. Holotype of *Polybotrya macbridei*, Macbride 5602 (US).

bus subpetiolulatis, superioribus sessilibus, quadrangularibus, 3.5–18 cm longis, 1.25–3(3.5) cm latis, basi plus minusve rotundatis subaequilateralibus (basi inferiore minime excavatis), apice acutis vel acuminatis, marginibus integris vel leviter crenatis, costis rectis sulcatis, subtus sparse paleaceis et sparse pilosis, costulis usque ad 35-jugis, venis 4–6, etiam vena intermedia simplici ex costa ad marginem necnon praeditis; laminae fertiles lanceolatae, basi obtusae, apice acutae, 40–60 cm longae, 11–17 cm latae, pinnato-pinnatifidae, pinnis 17–21 pairbus alternis vel suboppositis quadrangularibus, usque ad 14 cm longis, 1–2.4 cm latis, costis rectis sulcatis, pilosulis, segmentis 2–12 mm longis, 1–2 mm latis.

TYPE: Gamitanacocha, Río Mazán, alt 100–125 m, Dept. Loreto, Peru, *Schunke 268* (US; isotypes F, NY).

ADDITIONAL SPECIMENS EXAMINED:

ECUADOR: Napo-Pastaza: Basin of the Río Pastaza, Río Bobanaza and adjacent tributaries, ca. 1000 m, *Gill 47* (NY).

PERU: Loreto: Gamitanacocha, Río Mazán, alt 115 m, *Schunke 14285* (US); Mishuyacu, near Iquitos, alt 100 m, *Klug 1386* (F, US). **Huánuco:** Tingo María, alt 700 m, *Tryon & Tryon 5221* (GH, US).

This species is most closely allied to *P. macbridei*, from which it differs in having a thicker rhizome with pale reddish, dull rhizome scales and sterile pinnae that are not lobed or divided, as those of *P. macbridei* often are.

Polybotrya macbridei Lellinger, sp. nov. Figs. 2 and 9.

Planta hemiepiphytica; rhizoma scandens, 0.6–1 cm diam, dense paleaceum, paleis linearibus, usque ad 1 cm longis, 1 mm latis, concoloribus vel bicoloribus, atrobrunneis nitentibus, marginibus brunneis irregulariter dentatis; stipites 20–30 cm longi, 2–3(4) mm diam, straminei sulcati raro sparse villosuli in sulco, basi dense paleacei, sursum parce paleacei, paleis eis rhizomatis similibus praediti, usque ad 7 mm longis, 0.5 mm latis; rhachides stramineae sulcatae villosulae in sulco, parce paleaceae, paleis eis stipitum similibus praeditae; laminae steriles papyraceae, triangulo-lanceolatae, basi fere truncatae, apice acutae vel acuminatae, (33)40–60 cm longae, 20–30(38) cm latae, pinnatae vel bipinnatae apice pinnatifidae, pinnis 9–14 paribus alternis, inferioribus petiolulatis pinnatis, segmentis 1–5 liberis, lineari-lanceolatis basi inaequilateralibus (basi inferiore excavata) vel triangularibus basi aequilateralibus, superioribus sessilibus vel adnatis, lineari-lanceolatis, basi inaequilateralibus, (5)7–17(26) cm longis, (1.5)2–4(9) cm latis, marginibus crenato-serratis vel crenatis, costis rectis sulcatis, glabris in sulco, subtus glabris vel sparse pilosulis, costulis usque ad 20(26)-jugis, venis 7–10, vena intermedia simplici ex costa ad marginem necnon praeditis; laminae fertiles triangulo-lanceolatae, basi obtusae, apice acuminatae, 20–50 cm longae, (11)20–25 cm latae, pinnato-pinnatifidae, pinnis 11–15 paribus alternis linearibus vel lanceatis, usque ad 14 cm longis, 2.5 cm latis, costis rectis sulcatis, sparse paleaceis, segmentis 2–16 mm longis, 1.5–2.5 mm latis.

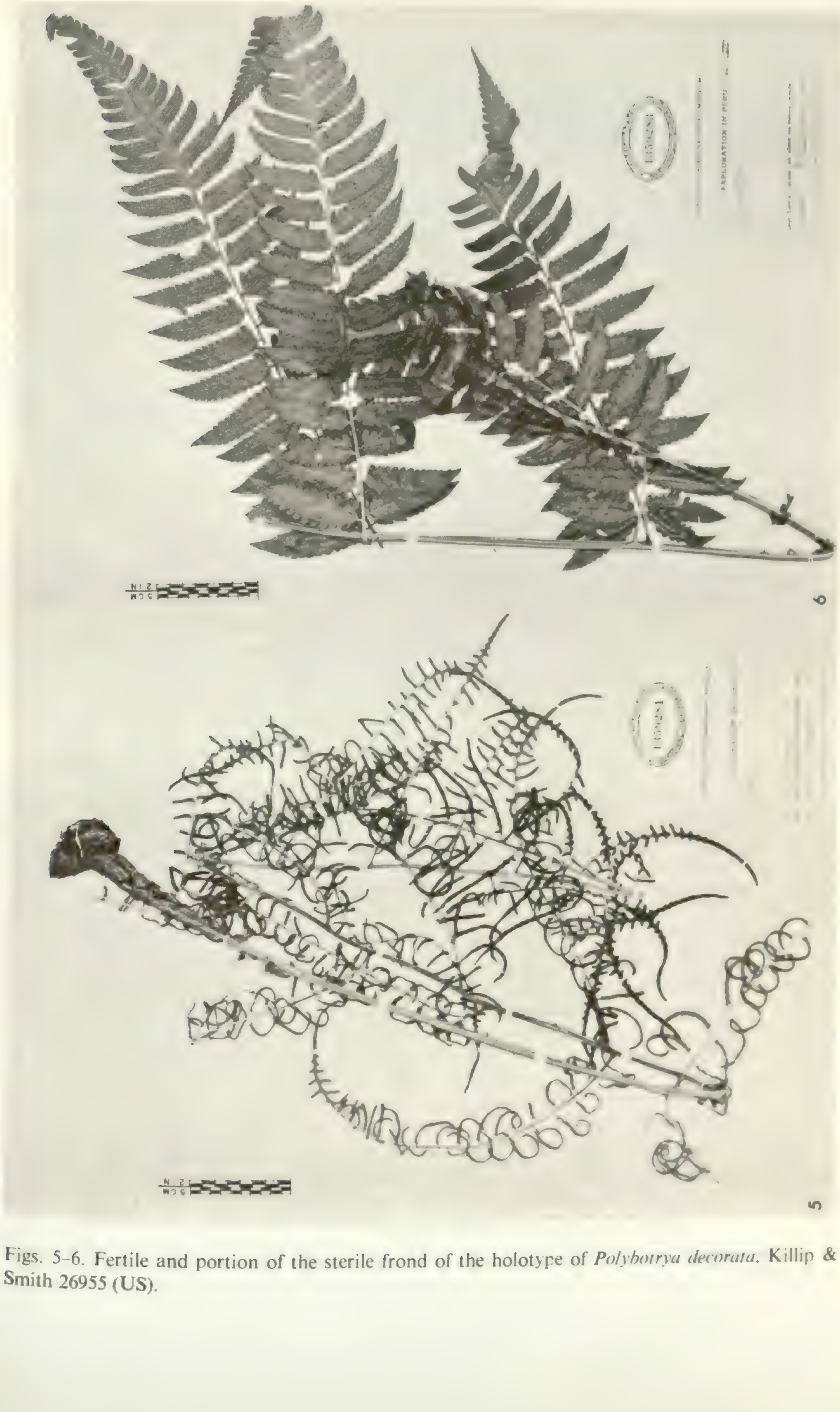
TYPE: Hacienda Schunke, La Merced, alt ca. 4000 ft, Dept. Junín, Peru, *Macbride 5602* (US; isotype F).

ADDITIONAL SPECIMENS EXAMINED:

PERU: Junín: La Merced, Chanchamayo, *Soukup 1065* (F), *Schunke 661, 812* (both F), alt 1200 m, *Schunke 157* (F), alt 1500 m, *Schunke 158* (F); Schunke Hacienda above San Ramón, alt 1400–1700 m, *Killip & Smith 24605* (NY, US).

This species is most closely related to *P. crassirhizoma*, from which it differs in having a thinner rhizome with dark brown, shining rhizome scales and sterile pinnae that towards the base of the fronds are fully pinnate with 1–5 free segments.

Figs. 3–4. Fertile and portion of the sterile frond of the holotype of *Polybotrya salicifolia*, Haught 1757 (US).



Figs. 5–6. Fertile and portion of the sterile frond of the holotype of *Polybotrya decorata*. Killip & Smith 26955 (US).

Polybotrya salicifolia Lellinger, sp. nov. Figs. 3, 4, and 10.

Planta hemiepiphytica; rhizoma scandens, 0.5–1(2?) cm diam, dense paleaceum, paleis anguste lanceolatis, usque ad 1.5 cm longis, 2 mm latis, concoloribus vel leviter bicoloribus, aureobrunneis nitentibus, marginibus sparse dentatis vel retrorso-dentatis; stipites 25–75 cm longi, 3–5 cm diam, straminei sulcati, pilosuli in sulco, basi dense paleacei, sursum parce paleacei, paleis linearibus, usque ad 2 cm longis, 0.5 mm latis, leviter bicoloribus, brunneis cum marginibus pallidioribus et sparse dentatis; rhachides stramineae sulcatae pilosulae in sulco, parce paleaceae, paleis eis stipitum similibus praeditae; laminae steriles papyraceae, lanceolatae, basi fere truncatae, apice abruptae, acuminatae in modum *Matteucciae struthiopteridis*, 40–75 cm longae, 25–45 cm latae, pinnatae apice pinnatifidae, pinnis 12–17 paribus alternis vel suboppositis, inferioribus petiolulatis, superioribus adnatis, anguste lanceolatis, (6)12–23 cm longis, (1)1.5–4 cm latis, basi plus minusve acutis inaequilateralibus (basi inferiore leviter excavata), apice acutis vel acuminatis, marginibus integris vel crenatis, ad apicem crenato-serratis, costis rectis sulcatis, pilosulis in sulco, subtus sparse pilosulis, costulis usque ad 25-jugis, venis 4–6; laminae fertiles lanceolatae, basi fere obtusae, apice abruptae, acuminatae, 30–65 cm longae, 15–25 cm latae, pinnato-pinnatifidae, pinnis 15–17 paribus alternatis vel suboppositis linearibus vel lanceatis, usque ad 12 cm longis, 0.5–2 cm latis, costis rectis sulcatis, sparse pilosulis in sulco, segmentis 1–12 mm longis, 1–2 mm latis.

TYPE: Vicinity of Puerto Berrio, between Carare and Magdalena Rivers, alt 100–700 m, Dept. Santander, Colombia, *Haught 1757* (US).

ADDITIONAL SPECIMENS EXAMINED:

COSTA RICA: Alajuela: Alajuelita, alt 900 m. *Alfaro 8073* (US). **San José:** El Rodeo, 4 Feb 1938, *Knight* (US). **VENEZUELA: Aragua:** Parque Nacional "H. Pittier," alt 1100 m, *Steyermark, Agostini & Lourteig 95827a* (US, VEN?). **COLOMBIA: Magdalena:** Santa Marta, *H. H. Smith 1052* (NY, US). **Cundinamarca:** Quebrada de Agua de Diosito, alt 530 m, *Murillo & Jaramillo 289* (US).

This species is most closely related to *P. fractiserialis* (and *P. plumbicaulis*, if that is different), from which it differs in its scaly stipes and rhachises and its generally narrower pinnae with crenate-serrate apices.

Polybotrya decorata Lellinger, sp. nov. Figs. 5, 6 and 11.

Planta hemiepiphytica; rhizoma scandens, 1–1.5 cm diam, dense paleaceum, paleis adpressis lanceolatis, usque ad 2.5 cm longis, 4 mm latis, leviter bicoloribus ad basin, flavo-brunneis obscuris, marginibus subtiliter erosis; stipites 10–30 cm longi, 2.5–4 mm diam, straminei sulcati, pilosi vel villosuli, basi dense paleacei, sursum parce paleacei, paleis usque ad 2 cm longis, 2.5 mm latis, concoloribus, flavo-brunneis, obscuris, marginibus subtiliter erosis; rhachides stramineae sulcatae pilosae, non paleaceae; laminae steriles papyraceae, triangulo-lanceolatae, basi obtusae vel fere truncatae, apice acutae vel acuminatae, 50–90 cm longae, 25–50 cm latae, bipinnato-pinnatifidae ad basin, sursum bipinnatae, apice pinnatifidae, pinnis 17–20 paribus alternis vel suboppositis, inferioribus petiolulatis pinnato-pinnatifidis, basi aequilateralibus, usque ad 25 cm longis, 10 cm latis, pinnulis ca. 10 paribus liberis, usque ad 5 cm longis, 1.5 cm latis, costulis ca. 12-jugis, venis 8, superioribus sessilibus vel adnatis, lineari-lanceolatis, basi aequilateralibus, 5–20 cm longis, 1.5–4 cm latis, pinnatifidis vel lobatis, marginibus crenatis, costis rectis sulcatis, villosulis in sulco, subtus plus minusve glabris, costulis usque ad 25-jugis, venis 8–18; laminae fertiles triangulo-lanceolatae, basi obtusae, apice acutae, 50–75 cm longae, 15–30 cm latae, pinnato-pinnatifidae vel bipinnatae, pinnis 17–20 paribus alternis vel suboppositis linearibus vel lanceatis, usque ad 15 cm longis, 4(9) cm latis, costis rectis sulcatis, pilosulis, segmentis 0.2–5 cm × 2–3 mm.

TYPE: Iquitos, alt ca. 100 m, Dept. Loreto, Peru, *Killip & Smith 26955* (US; isotype NY).

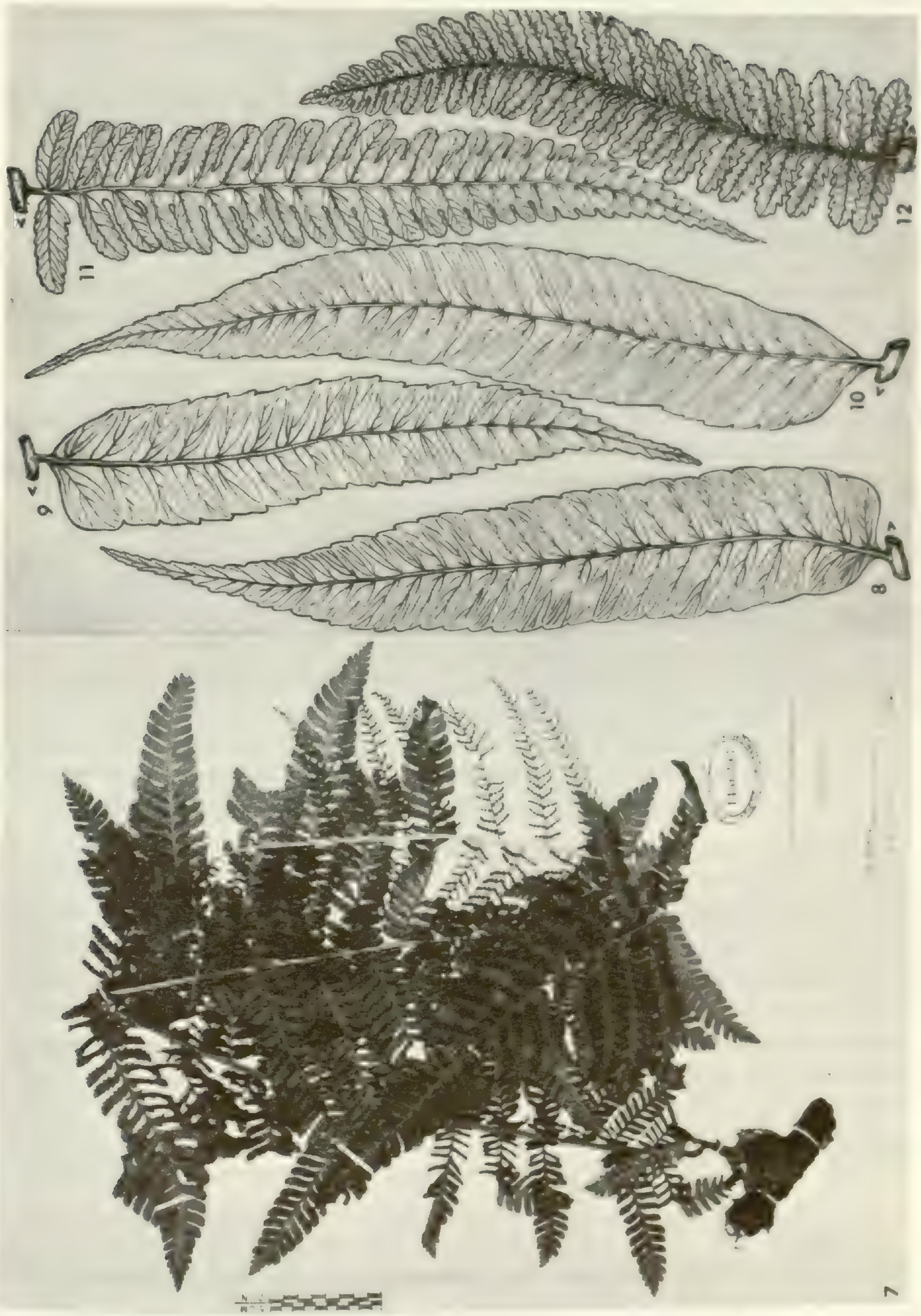


Fig. 7. Holotype of *Polybotrya subelliptica*, Klug 1390 (US). Figs. 8–12. Outline and venation of portions of sterile pinnae of *Polybotrya*. Fig. 8. *P. crassirhizoma*. Fig. 9. *P. macbridei*. Fig. 10. *P. salicifolia*. Fig. 11. *P. decorata*. Fig. 12. *P. subelliptica*.

ADDITIONAL SPECIMENS EXAMINED:

COLOMBIA: Amazonas-Vaupés: Soratama and vicinity, above mouth of the Río Kananarí, alt ca 900 ft, *Schultes & Cabrera 16053* (GH, US). **PERU: Junín:** Puerto Bermudez, alt ca 375 m, *Killip & Smith 26543* (US).

The rhizomes and rhizome scales of this species resemble those of *P. pubens* Mart., but the fronds bear a much sparser indument.

Polybotrya subelliptica Lellinger, sp. nov. Figs. 7 and 12.

Planta hemiepiphytica; rhizoma scandens, ca. 1 cm diam, dense palaeceum, paleis lanceatis, incurvis, usque ad 2 cm longis, 1.5 mm latis, leviter bicoloribus, parte centrali crassissima obscure brunneis, marginibus subtiliter erosis, fere stramineis; stipites ca. 2.5 cm longi, 3 mm diam, straminei sulcati, hirti in sulco, basi paleacei, paleis eis rhizomatis similibus praediti, sursum parce paleacei, paleis linearibus, usque ad 1 cm longis, 0.5 mm latis, concoloribus vel leviter bicoloribus, brunneis, marginibus integris; rhachides stramineae sulcatae hirtae, parce paleaceae, paleis linearibus, usque ad 6 mm longis, 0.1(0.3) mm latis, concoloribus brunneis; laminae steriles papyraceae, subellipticae, basi obtusae (pinnis basilibus 4.5 cm longis), apice acuminatae, ca. 75 cm longae, 22–28 cm latae, pinnato-pinnatifidae vel bipinnato-pinnatifidae, apice pinnatifidae, pinnis ca. 35 paribus alternis vel suboppositis, inferioribus sessilibus vel subpetiolulatis, superioribus adnatis, pinnis minoribus pinnatifidis, lanceatis vel quadrangularibus, 3–7 cm longis, 0.6–2 cm latis, segmentis quadrangularibus, 10–20 jugis, 4–10 mm longis, 2–4 mm latis, marginibus integris crenatis vel crenato-lobatis, venis 4–8, pinnis maioribus pinnato-pinnatifidis, lineari-lanceatis, 5–16 cm longis, 2.5–3.5(4) cm latis, pinnulis 20–25 jugis, quadrangularibus, 12–20 mm longis, 4–6 mm latis, crenatis vel lobatis, basi subaequilateralibus obtusis vel truncatis, apice acutis, costis rectis sulcatis, hirtis in sulco et subtus in sulco et venis; laminae fertiles anguste ellipticae, basi incognitae, apice acuminatae, ca. 45 cm longae, 15 cm latae, bipinnato-pinnatifidae, pinnis ca. 25 paribus alternis vel suboppositis linearibus vel lanceatis, usque ad 8 cm longis, 2.5–18 mm latis, costis rectis subsulcatis, sparse pilosis, pinnis usque ad 1 cm longis, 2.5 mm latis, segmentis ca. 1.5 mm longis et latis.

TYPE: Mishuyacu, near Iquitos, alt 100 m, Dept. Loreto, Peru, *Klug 1390* (US; isotypes F, NY).

The rhizome scales of this species are similar to those of *P. caudata*, but the sterile fronds are quite densely hirtous; the fertile fronds are much more delicate, more divided, and the pinnules lack the entire, caudate tips of those of *P. caudata*. *Polybotrya subelliptica* has sterile blades hirtous like those of *P. pubens*, but differs in the subelliptical lamina shape and in the narrow, stiff rhizome scales that are several cells thick at the center.

LITERATURE CITED

BRADE, A. C. 1969a. Algumas espécies novas de Filicineas de Costa Rica da coleção Alfred & Alexander Curt Brade. Bradea **1:** 11–17, *t. 1–5.*

———. 1969b. Duas espécies novas do genero Polybotrya (Polypodiaceae) da Venezuela. Bradea **1:** 19–21, *t. 1–2.*

———. 1969c. Algumas espécies novas do genero Polybotrya da Flora do Brasil. Bradea **1:** 23–28, *t. 1.*

FÉE, A. L. A. 1845. Histoire des Acrostichées [Mém. Fam. Foug. 2]. 114 pp. 64 pl. Veuve Berger-Levrault, Strasbourg.

LELLINGER, D. B. & E. R. DE LA SOTA. 1972. Collecting ferns in the Chocó, Colombia. Amer. Fern J. **62:** 1–8.

Date of Publication of Sodiro's "Cryptogamae Vasculares Quitenses"

C. V. MORTON*

Father Luis Sodiro, who Latinized his name as Aloisius Sodiro, was a member of the Society of Jesus and a teacher in Ecuador during the latter part of the nineteenth century and the early years of this century. He collected plants extensively for about thirty years, mostly on high mountain peaks like Corazón and Pichincha that are not far from Quito. Although he did publish on other groups, his specialty was ferns, an interest that culminated in his book "Cryptogamae Vasculares Quitenses Adiectis Speciebus in Aliis Provinciis Ditionis Ecuadorensis Hactenus Detectis," which, as the full title indicates, was a treatment of all known Ecuadorean Pteridophyta, not just those of the Province of Quito. This work is the only complete treatment of Ecuadorean ferns, or indeed of the ferns of any Andean country. Although the work follows the nomenclature of Hooker and Baker's "Synopsis Filicum" (ed. 2, 1874) and is consequently a hundred years out of date, it is still a useful, in fact indispensable work for the student of South American ferns.

Sodiro sent many specimens to Kew for study by J. G. Baker, who described numerous new species based on them, but Sodiro himself also described many new species, first in his "Recensio Cryptogamarum Vascularium Quitensium" (1883), and many more in the larger work mentioned above. This is dated 1893 and is always so cited. Two years ago I chanced to use the copy in the library at the Royal Botanic Gardens, Kew, and I found that its copy was not the usual bound published copy, but a copy consisting of parts as published in the "Anales de la Universidad de Quito." The Kew copy is incomplete, but it clearly shows that this work was actually published in parts, which were subsequently repaged and brought together in book form.

A check with a full series of these "Anales" in the Library of Congress shows that the "Cryptogamae Vasculares Quitenses" was really published in parts, some prior to 1893 and some later. The beginning was in series IV, no. 31, dated October 15, 1890, pp. 284–291. This part contains the key to the families and the treatment of the Hymenophylleae down through the account of *Trichomanes radicans*. This first part is different from the later published book, being written all in Latin. It can be presumed that the University authorities, or Sodiro's friends, convinced him that his work would be more accessible if it were written in Spanish, for this first part was republished two years later in ser. VI, no. 44, pp. 58–74. March, 1892, with the keys now in Spanish and the descriptions in both Latin and Spanish, the latter sometimes longer. This later published part contains additional material (down through part of the key to *Hymenophyllum*), and is exactly like the opening pages of the published book except for the pagination.

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After March, 1892, a part of the work appeared in almost every issue of the "Anales," finishing up the main body of the text in June, 1895, with an "Addenda et Corrigenda" appearing in October, 1897. If the complete book had really been published in 1893, there would have been no reason to continue with the publication of the text in parts in the "Anales." There is thus good reason to believe that the original publication continued to be in the "Anales" and that the published date on 1893 on the title page is incorrect. There is internal evidence also to this effect. For instance, in the account of *Nephrodium semilunatum* Sodiro in the "Anales," published in one of the numbers in 1894, the reference to the original publication of the species by Sodiro in his "Recensio" was accidentally omitted, but in the book this necessary information was added, a clear indication that the book could not have been published in 1893.

Sodiro wrote in the "Prologo" to the book "Durante mi permanencia de 23 años en esta republica con el cargo de Profesor de Botánica en la Universidad Central . . ." It seems, from the information available to me, that the title of the Universidad de Quito was not officially changed to "Universidad Central de Ecuador" until November 1, 1895, and so it is not likely that Sodiro would have so used it in 1893. This "Prologo" is dated August 15, 1893, but it is likely that this is merely the date when Sodiro wrote most of it, not the publication date of the book. In fact, the date of publication of the book is not of great importance perhaps, since the new species and varieties were published previously in the "Anales," except for a very few names that appear in the "Addenda et Corrigenda" on pages 638–644, which appear only in the book and not in the "Anales."

The only contemporary review that I have found is that by C. Brick in "Just's Botanischer Jahresbericht" (vol. 21, no. 1, p. 254. 1896). Brick's work for this journal is mentioned in the "Bericht für das Jahr 1895 des Botanischen Museums und des Laboratoriums für Waarenkunde zu Hamburg (Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten, vol. 13. 1896), which indicates that the review was written by Brick in 1895. The book used by Brick, who was chief of the Abteilung für Pflanzenschutz of the Staatsinstitut für Allgemeine Botanik, Hamburg, is not at present in the Institute, according to its present Director, Dr. K. Walther. It was probably a copy of the parts as issued in the "Anales" (like the Kew copy), for Brick indicated that it was published by the Universidad Central de Ecuador, and as noted above the name of the Universidad de Quito was not changed to Universidad Central until November 1, 1895. The Hamburg copy of the book is one of the books recently acquired in 1897, having been purchased from Lechevalier in Paris. I believe, therefore, that the book with the title-page date 1893 was not published until 1897, but that the parts were available by the end of 1895, that is the parts separated from the rest of the material that was published in the "Anales." Many of the novelties of Sodiro are indicated in the Gray Card Catalogue as published in the "Anales," but always with an accompanying reference to the "Cryptogamae Vasculares," which is always dated 1893. Some of these references to the "Anales" are wrongly dated, and on some cards this reference to the "Anales" is completely omitted. Quite a number of

names published by Sodiro, mostly those where the combination was attributed to the wrong author, have been accidentally omitted from the Gray Cards.

It is at present difficult to decide definitely on Sodiro's types. His collections are widely scattered. Unfortunately, he did not number his specimens consecutively. And many specimens have only vague data like "in reg. subtrop.," with or without a date. Some of the species were similarly published without any definite localities, e.g. *Nephrodium subglabrum,* where the only indication of the locality is "Crece en la región tropical y subtropical de 400–1200 metros." This can not be taken to mean necessarily that Sodiro had more than one specimen in hand, merely that he had seen the species in different places, at least two, one in the tropical zone at 400 meters and one in the subtropical at 1200 meters. Unfortunately, Sodiro also had the habit of going back to a place where he had found a new species and collecting additional material, which was also marked "n. sp." even though it may have been collected after the species had been already published. The only way that one can decide on probable isotypes or syntypes is by comparing the label data closely with the published data and by observing the date of collection (if given). The handwriting may give some additional clues, but many of the labels are not in Sodiro's own hand but were written by Father Mille or other associates. Sodiro's own herbarium is said to be still in Quito, but in poor condition and not available for consultation. It may be so, but this should be verified. There are large sets in Kew, Paris, and Berlin, and there are said to be 6000 specimens in the National Museum in Budapest, which, if true, may be the largest set of all. The types of the species described by Baker on Sodiro collections are at Kew, of course.

I indicate below the dates of the parts as issued. The parts often end in the middle of a sentence, and the pagination is not at all the same as in the book. I then give a list of the new species, varieties, and combinations with the correct citations.

DATES OF PUBLICATION OF THE PARTS OF THE "CRYPTOGAMAE VASCULARES QUITENSES"

Anal. Univ. Quito IV (31): 284–291. Oct. 15, 1890. Contains beginning through Trichomanes radicans, but with different text.
Ibid. VI (44): 58–74. Mar. 1892. Book pp. 1–16.
Ibid. VI (45): 146–154. Apr. 1892. Book pp. 17–24, line 41.
Ibid. VI (46): 229–237. May, 1892. Book pp. 24, bottom line–32, line 31.
Ibid. VI (47): 373–380. Jun. 1892. Book pp. 31, line 32–39, line 33, plus footnote.
Ibid. VII (49): 79–86. Aug. 1892. Book pp. 39, line 34–47, line 21.
Ibid. VII (50): 103–118. Sep. 1892. Book pp. 47, line 22–62.
Ibid. VII (51): 173–190. Oct. 1892. Book pp. 63–80, line 23.
Ibid. VII (53): 298–306. Dec. 1892. Book pp. 80, line 23–88, line 40.
Ibid. VIII (54): 8–15. Jan. 1893. Book pp. 88, line 41–96, line 22.
Ibid. VIII (55): 65–80. Feb. 1893. Book pp. 96, line 23–111, line 39.
Ibid. VIII (56): 141–157. Mar. 1893. Book pp. 111, line 30–128, line 16.
Ibid. VIII (57): 209–217. Apr. 1893. Book pp. 128, line 17–136, line 46.
Ibid. VIII (58): 261–276. May, 1893. Book pp. 136, line 47–152, line 3.

Ibid. VIII (59): 363–371. Jun. 1893. Book pp. 152, line 4–160, line 28.
Ibid. IX (60): 1–17. Jul. 1893. Book pp. 160, line 29–176, line 26.
Ibid. IX (61): 75–91. Aug. 1893. Book pp. 176, line 27–192, line 24.
Ibid. IX (62): 155–171. Sep. 1893. Book pp. 192, line 25–207, line 36.
Ibid. IX (63): 219–235. Oct. 1893. Book pp. 207, line 37–222, line 21.
Ibid. IX (64): 310–320. Nov. 1893. Book pp. 222, line 22–237, line 38.
Ibid. IX (65): 365–373. Dec. 1893. Book pp. 237, line 39–245.
Ibid. X (66): 1–17. Jan. 1894. Book pp. 246–261, line 39.
Ibid. X (67): 119–142. Feb. 1894. Book pp. 261, line 40–284, line 9.
Ibid. X (68): 185–210. Mar. 1894. Book pp. 284, line 10–306, line 40.
Ibid. X (69): 301–324. Apr. 1894. Book pp. 306, line 41–330, line 8.
Ibid. X (71): 389–406. Jun. 1894. Book pp. 330, line 9–346, line 33.
Ibid. XI (72): 23–46. Jul. 1894. Book pp. 346, line 34–369, line 42.
Ibid. XI (73): 109–133. Aug. 1894. Book pp. 369, line 43–394, line 8.
Ibid. XI (74): 199–224. Sep. 1894. Book pp. 394, line 9–418, line 38.
Ibid. XI (75): 312–336. Oct. 1894. Book pp. 418, line 39–442, line 9.
Ibid. XI (76): 446–470. Nov. 1894. Book 442, line 10–465, line 30.
Ibid. XI (77): 541–565. Dec. 1894. Book pp. 465, line 31–489, line 31.
Ibid. XII (78): 20–44. Jan. 1895. Book pp. 489, line 32–513, line 23.
Ibid. XII (79): 114–138. Feb. 1895. Book pp. 513, line 24–536, line 32.
Ibid. XII (80): 231–254. Mar. 1895. Book pp. 536, line 33–559, line 19.
Ibid. XII (81): 314–337. Apr 1895. Book pp. 559, line 20–582, line 11.
Ibid. XII (82): 395–418. May, 1895. Book pp. 582, line 12–605, line 5.
Ibid. XII (83): 475–502. Jun. 1895. Book pp. 605, line 6–631.
Anal. Univ. Central Republ. Ecuad. XIII (84): 46–75. Oct. 1897. This is the "Addenda et Corrigenda," with references to the pages of the "Anales" where new material is to be added or corrected, plus the chapters on "Climatología y Distribución Georgráfica," "Propriedades y Usos," and the "Indice," which gives references to the volumes and pages in the "Anales." In the book this material occupies pages 632–656, plus the unpaged index. The material of the "Addenda and Corrigenda" has been completely reset, giving references to the appropriate pages in the book rather than the "Anales" and with more additions and corrections inserted. The "Indice" also has been reset, with references given to pages in the book rather than the "Anales." Some names in the index in the "Anales" are omitted in the index to the book, and probably vice versa although I have not checked this.

NEW SPECIES, VARIETIES, AND COMBINATIONS PUBLISHED BY SODIRO

Acrostichum assurgens var. hartwegii (Fée) Sodiro, op. cit. XI (77): 543. Dec. 1894. *Acrostichum hartwegii* Fée
A. chrysolepis Sodiro, op. cit. XI (77): 561. Dec. 1894.
A. corderoanum Sodiro, op. cit. XI (77): 546. Dec. 1894.
A. deltoideum Sodiro, op. cit. XI (77): 542. Dec. 1894.
A. flabellatum var. bipartitum Sodiro, op. cit. XI (77): 565, Dec. 1894.
A. hackelianum Sodiro, op. cit. XII (78): 21. Jan. 1895.
A. hirtipes Sodiro, op. cit. XI (76): 447. Nov. 1894.
A. isophyllum Sodiro, op. cit. XI (75): 335. Oct. 1894.
A. latifolium var. alismifolium (Fée) Sodiro, op. cit. XI (75): 325. Oct. 1894. *Acrostichum alismifolium* Fée
A. latifolium var. luridum (Fée) Sodiro, op. cit. XI (75): 325. Oct. 1894. [wrongly attributed to Fée]. *Acrostichum luridum* Fée.

Acrostichum latifolium var. scalpellum (Mart.) Sodiro, op. cit. XI (75): 325. Oct. 1894. *Acrostichum scalpellum* Mart.
A. latifolium var. subsessile Sodiro, XI (75): 325. Oct. 1894.
A. lepidotum var. cupreum Sodiro, op. cit. XI (77): 557. Dec. 1894.
A. microlepis Sodiro, op. cit. XI (75): 331. Oct. 1894.
A. muscosum var. macropodum Sodiro, op. cit. XI (77): 549. Dec. 1894.
A. rimbachii Sodiro, op. cit. XI (77): 554. Dec. 1894.
A. setigerum Sodiro, op. cit. IV: 174. 1890.
A. sorbifolium var. anceps Sodiro, op. cit. XI (77): 560. Dec. 1894.
A. stenophyllum Sodiro, op. cit. XI (77): 544. Dec. 1894.
A. viscosum var. dissidens Sodiro, op. cit. XI (76): 465. Nov. 1894. [as "disidens"].
Adiantum aethiopicum var. viridissimum Sodiro, op. cit. VII (51): 179. Oct. 1892.
Alsophila bakeri Sodiro, op. cit. XII (79): 134. Feb. 1895.
A. pruinata var. conspicua Sodiro, op. cit. XII (80): 232. Mar. 1895.
Aspidium contractum Sodiro, op. cit. IX (63): 234. Oct. 1893.
A. macropterum Sodiro, op. cit XIII (84): 49. Oct. 1895.
A. trilobum var. puberulum Sodiro, op. cit. IX (63): 233. Oct. 1893.
Asplenium bifrons Sodiro, op. cit. IX (61): 83. Aug. 1893.
A. debile Sodiro, op. cit. VIII (58): 266. May, 1893.
A. eggersii Sodiro, op. cit. IX (61): 87. Aug. 1893.
A. flavescens var. caucense (Karst.) Sodiro, op. cit. IX (61): 83. Aug. 1893 [wrongly attributed to Karst.]. *Asplenium caucense* Karst.
A. flavidum Sodiro, op. cit. VIII (58): 273. May, 1893.
A. hians var. pallescens Sodiro, op. cit. IX (62): 163. Sep. 1893.
A. leptochlamys Sodiro, op. cit. IX (62): 163. Sep. 1893.
A. macropterum Sodiro, op. cit. IX (62): 165. Sep. 1893.
A. melanopus Sodiro, op. cit. IX (61): 88. Aug. 1893.
A. meniscioides Sodiro, op. cit. IX (61): 88. Aug. 1893.
A. monanthemum var. menziesii (Hook. & Grev.) Sodiro, op. cit. VIII (58): 270. May, 1893. *Asplenium menziesii* Hook. & Grev.
A. ochraceum Sodiro, op. cit. IX (62): 171. Sep. 1893.
A. pulicosum var. maius Sodiro, op. cit. IX (62): 161. Sep. 1893.
A. reflexum Sodiro, op. cit. IX (62): 168. Sep. 1893.
A. rutaceum var. disculiferum Sodiro, op. cit. IX (61): 79. Aug. 1893.
A. trichomanes var. herbaceum Sodiro, op. cit. VIII (58): 269. May, 1893.
A. triphyllum var. compactum Sodiro, op. cit. IX (61): 76. Aug. 1893. [This may have been intended as the same as *A. triphyllum* var. *compactum* Hook. (Sp. Fil. 3: 203. 1860), but it has no reference to Hooker or any previous publication, and so must be considered a new, independent variety, a later homonym of that of Hooker.]
A. triphyllum var. gracillimum Sodiro, op. cit. IX (61): 76. Aug. 1893.
A. triphyllum var. herbaceum (Fée) Sodiro, op. cit. IX (61): 76. Aug. 1893 [wrongly attributed to Fée]. *Asplenium herbaceum* Fée.
Blechnum lomarioides Sodiro, op. cit. VIII (57): 209. Apr. 1893.
B. occidentale var. puberulum Sodiro, op. cit. VIII (57): 210. Apr. 1893.
B. scaberulum Sodiro, op. cit. VIII (57): 211. Apr. 1893.
Cheilanthes laciniata Sodiro, op. cit. VII (51): 189. Oct. 1892.
C. myriophylla var. elegans (Desv.) Sodiro, op. cit. VII (53). 300. Dec. 1892. *Cheilanthes elegans* Desv.
Cyathea borjae Sodiro, op. cit. XII (78): 35. Jan. 1895.
C. corallifera Sodiro, op. cit. XII (78): 39. Jan. 1895.

Cyathea corallifera var. firma Sodiro, op. cit. XII (78): 40. Jan. 1895.
C. corallifera var. ortholoba Sodiro, op. cit. XII (78): 40. Jan. 1895.
C. dyeri Sodiro, op. cit. XII (79): 116. Feb. 1895.
C. fulva var. minor Sodiro, op. cit. XII (79): 118. Feb. 1895.
C. purpurascens Sodiro, op. cit. XII (78): 34. Jan. 1895.
Dicksonia coronata (Sodiro) Sodiro, op. cit. VII (50): 104. Sep. 1892. *Dicksonia adiantoides* var. *coronata* Sodiro.
D. divaricata Sodiro, op. cit. VII (50): 104. Sep. 1892.
D. lagerheimii Sodiro, op. cit. VII (50): 106. Sep. 1892.
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D. scandens var. isotoma Sodiro, op. cit. VII (49): 86. Aug. 1892.
D. sellowiana var. arachneosa Sodiro, op. cit. VII (49): 83. Aug. 1892.
Drymoglossum wiesbaurii Sodiro, op. cit. XI (75): 312. Oct. 1894.
Gleichenia pubescens var blepharolepis (Sodiro) Sodiro, op. cit. VI (47): 376. Jun. 1892. *Gleichenia blepharolepis* Sodiro.
G. pubescens var. mathewsii (Hook.) Sodiro, op. cit. VI (47): 376. Jun. 1892. [wrongly attributed to Hooker]. *Gleichenia mathewsii* Hook.
Gymnogramma subscandens Sodiro, op. cit. XI (74): 206. Sep. 1894.
G. tortuosa Sodiro, op. cit. XI (74): 206. Sep. 1894.
Hemitelia subcaesia Sodiro, op. cit. XII (79): 124. Feb. 1895.
Hymenophyllum brachypus Sodiro, op. cit. VI (46): 233. May, 1892.
H. contractile Sodiro, op. cit. VI (45): 151. Apr. 1892.
H. divaricatum Sodiro, op. cit. VI (46): 234. May, 1892.
H. helicoideum Sodiro, op. cit. VI (45): 150. Apr. 1892.
H. nanum Sodiro, op. cit. VI (46): 232. May, 1892.
H. pendulum Sodiro, op. cit. VI (46): 236. May 1892.
H. rimbachii Sodiro, op. cit. XIII (84): 47. Oct. 1897.
H. sericeum var. refrondescens (Sodiro) Sodiro, op. cit. VI (46): 230. May, 1892. *Hymenophyllum refrondescens* Sodiro.
H. splendidum var. apodum Sodiro, op. cit. VI (45): 152. Apr. 1892.
Hypolepis flexuosa Sodiro, op. cit. XIII (84): 48. Oct. 1897.
Jamesonia imbricata var. nivea (Karst.) Sodiro, op. cit. XI (73): 127. Aug. 1894 [wrongly attributed to Karst.]. *Jamesonia nivea* Karst.
J. imbricata var. scalaris (Kunze) Sodiro, op. cit. XI (73): 127. Aug. 1894 [wrongly attributed to Kunzel]. *Jamesonia scalaris* Kunze.
Lomaria dendrophila Sodiro, op. cit. VIII (56): 148. Mar. 1893.
L. floresii Sodiro, op. cit. VIII (56): 144. Mar. 1893.
L. petiolaris Sodiro, op. cit. VIII (56): 143. Mar. 1893.
L. rimbachii Sodiro, op. cit. VIII (56): 146. Mar. 1893.
Lycopodium hartwegianum var. viridissimum Sodiro, op. cit. XII (81): 330. Apr. 1895.
L. polycladum Sodiro, op. cit. XII (81): 316. Apr. 1895.
L. reflexum var. intermedium Sodiro, op. cit. XII (81): 324. Apr. 1895.
L. reflexum var. minus Sodiro, op. cit. XII (81): 324. Apr. 1895 [non Spring, 1842].
L. reflexum var. polycarpum Sodiro, op. cit. XII (81): 324. Apr. 1895.
L. rimbachii Sodiro, op. cit. XII (81): 321. Apr. 1895.
L. riofrioi Sodiro, op. cit. XII (81): 337. Apr. 1895.
L. sarmentosum var. capillare (Sodiro) Sodiro, op. cit. XII (81): 328. Apr. 1895. *Lycopodium capillare* Sodiro.
L. taxifolium var. brongniartii (Spring) Sodiro, op. cit. XII (81): 330. Apr. 1895 [wrongly attributed to Spring]. *Lycopodium brongniartii* Spring.

Lycopodium tobarii Sodiro, op. cit. XII (81): 320. Apr. 1895.
Nephrodium crassipes Sodiro, op. cit. IX (64): 323. Nov. 1893.
N. crinitum var. glaucescens Sodiro, op. cit. X (66): 6. Jan. 1894.
N. elegantulum Sodiro, op. cit. IX (65): 371. Dec. 1893.
N. lagerheimii Sodiro, op. cit. X (66): 7. Jan. 1894.
N. nemorale Sodiro, op. cit. X (67): 124. Feb. 1894.
N. polylepis Sodiro, op. cit. X (66): 16. Jan. 1894.
N. rigescens Sodiro, op. cit. IX (65): 366. Dec. 1893.
N. squamosissimum Sodiro, op. cit. X (66): 12. Jan. 1894.
N. subglabrum Sodiro, op. cit. X (66): 15. Jan. 1894.
N. supinum Sodiro, op. cit. IX (65): 368. Dec. 1893.
N. urbanii (Sodiro) Sodiro, op. cit. XIII (84): 50. Oct. 1897. *Polypodium urbanii* Sodiro.
N. villosum var. spectabile (Kaulf.) Sodiro, op. cit. X (66): 14. Jan. 1894. *Polypodium spectabile* Kaulf.
N. villosum var. subincisum (Willd.) Sodiro, op. cit. X (66): 14. Jan. 1894. *Polypodium subincisum* Willd.
Nephrolepis cordifolia var. obtusata Sodiro, op. cit. X (67): 133. Feb. 1894.
Polypodium acuminatum (Fée) Sodiro, op. cit. XI (72): 31. Jul. 1894 [wrongly attributed to Fée]. *Goniophlebium acuminatum* Fée.
P. angustifolium var. gramineum Sodiro, op. cit. XI (72): 43. Jul. 1894.
P. angustifolium var. jamesonii (Fée) Sodiro, op. cit. XI (72): 43. Jul. 1894. *Campyloneuron jamesonii* Fée.
P. argyrolepis Sodiro, op. cit. XI (72): 26. Jul. 1894.
P. azuayense Sodiro, op. cit. X (69): 317. Apr. 1894.
P. caceresii Sodiro, op. cit. XI (72): 37. Jul. 1894.
P. chionolepis Sodiro, op. cit. XI (73): 114. Aug. 1894.
P. circinatum Sodiro, op. cit. X (71): 392. Jun. 1894.
P. ecostatum Sodiro, op. cit. X (69): 303. Apr. 1894.
P. heteromorphum var. variabile (Mett.) Sodiro, op. cit. X (69): 321. Apr. 1894 [wrongly attributed to Mett.]. *Polypodium variabile* Mett.
P. loriceum var. heterolepis Sodiro, op. cit. XI (72): 28. Jul. 1894.
P. loriceum var. nanegalense (Sodiro) Sodiro, op. cit. XI (72): 28. Jul. 1894. *Polypodium nanegalense* Sodiro.
P. mindense Sodiro, op. cit. XI (72): 25. Jul. 1894.
P. mixtum Sodiro, op. cit. X (71): 398. Jun. 1894.
P. moniliforme var. peruvianum (Desv.) Sodiro, op. cit. X (69): 311. Apr. 1894. [wrongly attributed to Desv.] *Polypodium peruvianum* Desv.
P. morlae Sodiro, op. cit. X (68): 206. Mar. 1894.
P. pectinatum var. brachypus Sodiro, op. cit. X (71): 394. Jun. 1894.
P. pectinatum var. recurvatum (Kaulf.) Sodiro, op. cit. X (71): 394. Jun. 1894 *Polypodium recurvatum* Kaulf.
P. pichinchae Sodiro, op. cit. X (69): 324. Apr. 1894.
P. rimbachii Sodiro, op. cit. XI (72): 32. Jul. 1894.
P. squamatum var. tridens (Kunze) Sodiro, op. cit. XI (72): 40. Jul. 1894. *Polypodium tridens* Kunze.
P. subandinum Sodiro, op. cit. XI (72): 24. Jul. 1894.
P. taxifolium var. filicula (Kaulf.) Sodiro, op. cit. X (71): 390. Jun. 1894 [wrongly attributed to Baker]. *Polypodium filicula* Kaulf.
P. tetragonum var. megalodus (Schkuhr) Sodiro, op. cit. X (68): 204. Mar. 1894 [wrongly attributed to Baker]. *Polypodium megalodus* Schkuhr.
P. urbanii Sodiro, op. cit. X (68): 203. Mar. 1894.

Pteris andreana Sodiro, op. cit. VIII (55): 71. Feb. 1893.
P. coriacea var. diffusa Sodiro, op. cit. VIII (54): 15. Jan. 1893.
P. hymenophylla Sodiro, op. cit. VIII (55): 70. Feb. 1893.
P. pedata var. gemmipara Sodiro, op. cit. VIII (55): 68. Feb. 1893.
P. sclerophylla Sodiro, op. cit. VIII (55): 69. Feb. 1893.
P. trialata Sodiro, op. cit. VIII (55): 76. Feb. 1893.
Selaginella eggersii Sodiro, op. cit. XII (82): 418. May, 1895.
S. filicaulis Sodiro, op. cit. XIII (82): 413. May, 1895.
S. lizaraburui Sodiro, op. cit. XII (83): 486. Jun. 1895.
S. poeppigiana var. versicolor Sodiro, op. cit. XII (83): 480. Jun. 1895.
S. reptans Sodiro, op. cit. XII (82): 411. May, 1895.
S. triuncialis Sodiro, op. cit. XII (82): 407. May, 1895.
S. wolfii Sodiro, op. cit. XII (83): 490. Jun. 1895.
Trichomanes axillare Sodiro, op. cit. IV (31): 291. Oct. 1890.
T. axillare var. helicoideum Sodiro, op. cit. IV (31): 291. Oct. 1890.
T. dactylites Sodiro, op. cit. VI (44): 70. Mar. 1892.
T. imbricatum Sodiro, op. cit. VI (44): 70. Mar. 1892.
T. krausii var. crispatum Sodiro. op. cit. IV (31): 289. Oct. 1890. [Perhaps intended to be the same as *T. krausii* var. *crispatum* Hook. & Bak. (Syn. Fil. 77. 1867), but to be considered nomenclaturally different, since there is no reference to Hooker and Baker.]
T. pyxidiferum var. debile (v. d. Bosch) Sodiro, op. cit. IV (31): 290. Oct. 1890. *Trichomanes debile* v. d. Bosch.
Vittaria longipes Sodiro, op. cit. XI (74): 222. Sep. 1894.

SHORTER NOTE

EQUISETUM PALUSTRE IN NORTH DAKOTA.—On July 6, 1969, while collecting for the University of Kansas, I discovered a colony of *Equisetum palustre* L. on the south side of the Sheyenne River, 16 miles east and 5 miles north of Lisbon, Ransom County, North Dakota. The large colony was growing in several inches of water in a wooded bog. This is the first record of the fern in North Dakota, although it has been recorded for surrounding states. Specimens of my collection, *Ralph Brooks 1554*, are on deposit in the herbaria of the University of Kansas (KANU) and North Dakota State University (NDA).

In June 1970 I revisited the colony and found it in excellent condition. Additional specimens were collected to further document my earlier findings. *Matteuccia struthiopteris* (L.) Todaro, an uncommon fern in North Dakota, was also found growing along the Sheyenne River near the *Equisetum* colony on this second visit.—*Ralph E. Brooks, Biology Department, Kansas State Teachers College, Emporia, KS 66801.*

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AMERICAN FERN JOURNAL

Volume 62

Number 3

July–September, 1972

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The "American Fern Journal" is an illustrated quarterly devoted to the general study of ferns. It is owned by the American Fern Society, and published at 3200 Falls Cliff Rd., Baltimore, Md. 21211. Second-class postage paid at Baltimore.

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LYCOPOD SPORES, I. General Spore Patterns and the Generic Segregates of Lycopodium[1]

JOAN H. WILCE*

The material presented here is part of an investigation undertaken to test the taxonomic validity of *Diphasium* Presl, a generic segregate of *Lycopodium* L. that seems to be winning increasing acceptance, particularly among European botanists. It was hoped that part of the answer to the *Diphasium* question might lie in the morphology of its spores. Prior to the development of scanning electron microscopy (SEM), lycopod spores had already been found taxonomically useful at several possible levels (Wilson, 1934; Knox, 1950; Harris, 1955; Wilce, 1965). Use of SEM could be expected to increase greatly the available data on *Lycopodium* spore surface patterns. By including in the study spores of a large, representative sample of lycopod species, I hoped to be able to evaluate the other generic segregates of *Lycopodium* as well as to help settle the status of *Diphasium*.

The extensive literature regarding generic segregates of *Lycopodium* has been reviewed regularly and need not be repeated here (Pritzel, 1900; Rothmaler, 1944; Boivin, 1950; Löve & Löve, 1958; Wilce, 1965.) The large number of different taxonomic treatments given to *Lycopodium* reflects the differing perspectives with which systematists have approached the group, coupled with their sometimes rather divergent philosophic views of the proper goals of biological systems of classification.

Past studies of *Lycopodium* spores, except for Knox's (1950) extensive survey, have been limited in scope, dealing either with a single group of species (Wilce, 1965) or with specific floras. The present study includes nearly half of the species Herter (1950) includes in *Lycopodium s. str.* but only about 12% (48 taxa) of those he lists under *Urostachys* (the proper name for which is *Huperzia* Bernh.). Knox (1950) reports on 33 additional species in the latter group and five in *Lycopodium s. str.* not represented in this study.

Spores of many lycopod taxa remain unexamined. Future study of these spores will probably aid in determining relationships between taxa in cases where affinities may otherwise be obscured. It seems doubtful, however, that additional spore types will be found within the group. This survey, while giving a much better view of the spores than earlier methods permitted, has turned up no new major spore patterns, with the exception of the scabrate type found in *Lycopodium casuarinoides*. Certainly for purposes of lycopod systematics above the species level ample information is at hand.

---

* Department of Botany, University of Massachusetts, Amherst, MA 01003.

[1] Research supported by NSF Project 8068 and by the University of Massachusetts, Amherst, Mass., through the use of its facilities. I wish to thank Rolla M. Tryon, Jr., David B. Lellinger, George R. Proctor, and Harry Ahles for making available most of the materials used in this study. I am especially indebted to Richard Turnage (A M R, Burlington, Mass.), whose skill in SEM made it possible to include more species in the study than initially expected. Finally, my thanks go to Robert T. Wilce.

Volume 62, number 2, of the Journal, pp. 33–64, was issued July 26, 1972.

MATERIALS AND METHODS

The 161 spore samples studied and photographed in this SEM study represent a tentative 89 species and several varieties (the synonymy of certain taxa is not yet clear). Names assigned to taxa with which I have little personal experience are tentative; in such cases (particularly within the *Huperzia* element) I have had to rely on the determination from the specimen label.

Samples were collected from specimens housed in the herbaria of the following institutions: Gray Herbarium (GH), Smithsonian (US), Institute of Jamaica (IJ), and the Universities of California (UC) and Massachusetts (MASS). Specimens were selected giving preference to those collections with widest distribution and most recent date. Specimens chosen were morphologically representative of the taxa to the best of my knowledge. Spores were first examined under the light microscope, and samples with excessive abortion were eliminated from the study.

Samples were mounted on SEM specimen stubs with "Scotch" double-sided tape and coated with a thin layer of carbon followed by gold paladium. Specimens were examined using the A M R Scanning Electron Microscope, normally working at 20 kv and an angle of 45°. Both 100 μ and 200 μ apertures were used with good results. Photographs were taken using "Polaroid" 55 P/N film.

Photographs were taken mainly at magnifications of 2,000 $\times$ and 10,000 $\times$, although additional observations and photographs were made at various other magnifications ranging up to 24,000 $\times$. Greater photographic coverage was given to species within *Lycopodium s. str.* (usually 7 to 9 photographs per species) than for those representing *Huperzia* (averaging 4 photographs per species). Samples were observed carefully before photographing to make sure representative spores were selected.

Studies of certain species were extensive, involving population sampling and a comparison of acetylated and air-dried material. The study of *Lycopodium clavatum* included 40 photographs; that of *L. complanatum* 68 photographs. Most such studies, however, included between 18 and 36 photographs.

PRELIMINARY SURVEY

The descriptive terminology in the following paragraphs follows that used by Faegri and Iverson (1950) and Harris (1955).

A preliminary survey was made of spores of well known taxa in the various sections of the genus, which showed spore form to be quite consistent within a sample and between samples of the same taxon from widely separated localities. A certain amount of variation was noted between individual spores, but that variation did not change the general aspect. The spores of some species seemed nearly indistinguishable, whereas others were readily distinguished. Age did not appear to affect the spore surfaces significantly.

In addition, samples of 20 species were acetylated and compared with air-dried spores from the same specimen. In some cases the acetylated spores showed surface detail at high magnifications somewhat more clearly than did air-dried spores, but at the expense of spore shape. The acetylated spores of numerous species collapsed

as they dried on the specimen stub, the proximal spore wall sinking into the spore cavity.

Because major surface features are plainly seen and in most cases high magnification work is satisfactory in air-dried material, for the remainder of the study spores were not acetylated. For comparisons of spores at the species level, however, examination of both air-dried and acetylated material of each sample obviously will yield the best results.

In the main survey, only one major new spore type has been found. A certain amount of interesting variation was noticed between some species within groups, but it is not my purpose at this time to describe the spores of each species studied; the focus here is on the broader differences that characterize the spore types and on the taxonomic implications of these types. Ornamentation patterns of the spore wall in *Lycopodium* fall into five broad classes noted below.

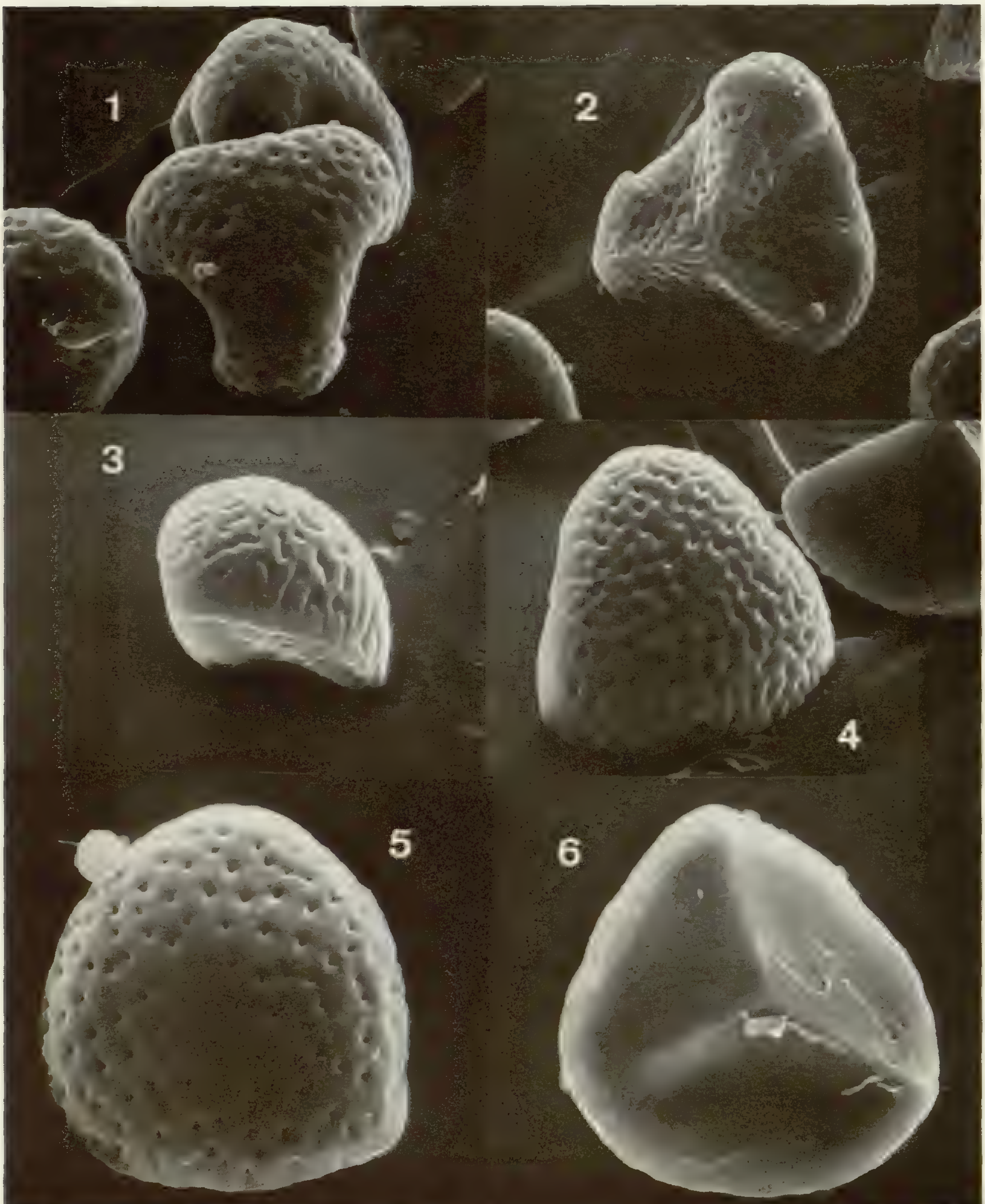
THE FOVEOLATE-FOSSULATE GROUP

The spores of all species examined that belong to the *Huperzia* element of *Lycopodium* fall into the foveolate-fossulate group. These spores can be described generally as free, anisopolar, radiosymmetrical, tetrahedral, and trilete, with laesurae extending to or nearly to the margin. Ornamentation ranges from pitted (foveolate), through a series of intermediate stages in which the pits have sloping walls, to a coalescing of the pits into grooves (fossulate). Surface texture ranges from very smooth to finely pebbled.

Two distinct, although apparently related spore types can be recognized within this broad group, primarily based upon spore outline (contour as seen in polar view), but correlated with other differences as well. No special status is implied for the well-known species from which are taken the names of these or any subsequently described spore types.

THE SELAGO TYPE (*Figs. 1–2*).—Spore outline is modified from triangular by concave sides and truncate angles. Laesurae are more or less prominent as ridges. Pits or grooves occur on both proximal and distal surfaces. Species may differ in spore size, degree of concavity of the sides, depth, diameter, and spacing of pits on the distal surface, and the prominence of the proximal pitting. Species studied with spores of this type are: *Lycopodium lucidulum, L. quasipolytrichoides, L. selago, L. serratum,* and *L. squarrosum.* To this list may be added *L. celanicum, L. miniatum, L. fontinaloides* (Knox, 1950), and *L. australianum* (Harris, 1955).

THE PHLEGMARIA TYPE (*Figs. 3–6*).—Spores are subtriangular in outline, with the sides straight to somewhat convex and the angles rounded. Laesurae range from a relatively prominent ridge to (more commonly) hardly more than corners where the three contact faces meet. Species may differ in spore size and ornamentation, although spores of many seemed nearly indistinguishable. Distal ornamentation ranges from foveolate (*Fig. 5*) in some species to strongly fossulate (*Fig. 3*) in others; still others show various intermediate conditions (*Fig. 4*). Knox separated the fossulate from foveolate types into two different groups; the number of intermediate types seems to discourage this distinction. Proximal surfaces are un-



Lycopodium spores. Fig. 1. Distal view of *L. lucidulum*, × 1400 (Leverett, Mass., 13 Nov 1969, *Wilce*, MASS). Fig. 2. Same, proximal view, × 1400. Fig. 3. Equatorial view of *L. dichotomum*, × 1400 (Oaxaca, Mexico, *Mexia 9141a*, GH). Fig. 4. Intermediate fossulate-foveolate condition of *L. reflexum*, × 1400 (Macchu Picchu, Peru, 19 May 1970, *Wilce*, MASS). Fig. 5. Distal view of *L. billardieri*, × 1400 (New Zealand, *Chapman* in 1944, GH). Fig. 6. Same, proximal view, × 1400.

ornamented (*Fig. 6*) in nearly all species; in several there were suggestions of very shallow pits.

Species studies with this spore type are too numerous to list here. They will be discussed in greater detail and listed in a later paper. *Lycopodium casuarinoides* was placed in this group by Knox (1950), but does not belong here. Possibly the error resulted from a confusion of samples, since the plant itself is quite recognizable.

THE RUGULATE GROUP

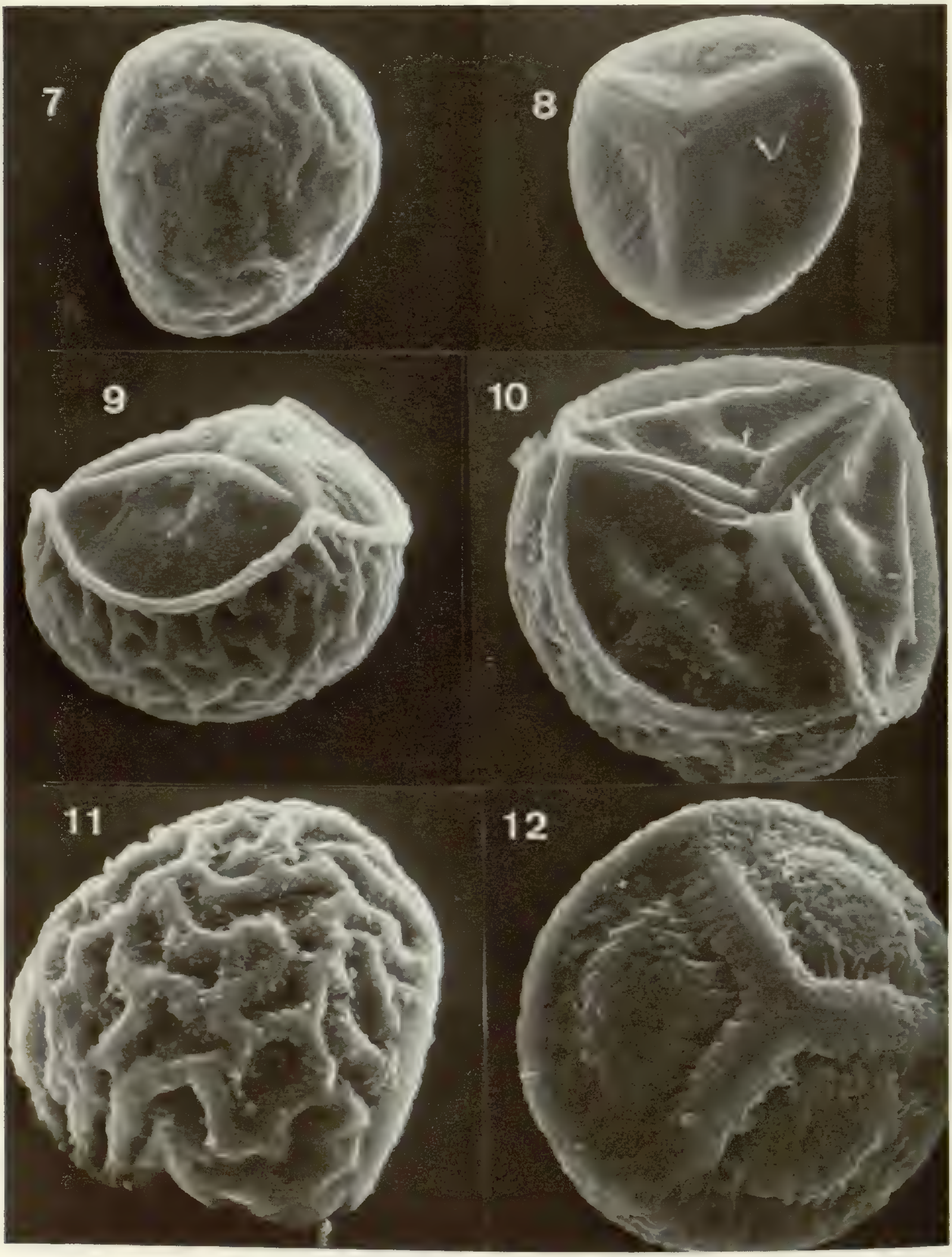
The cluster of species with spores falling into the rugulate group thus far coincides exactly with *Lepidotis* Palisot as redefined by Rothmaler (1944). Spores in this group are circular or nearly so in outline, with grooved laesurae having a usually prominent margo. The distal ornamentation ranges from prominent anastomosing ridges that approximate a reticulum (*Fig. 11*) to nearly no ornamentation at all with only slight surface undulations (*Lycopodium pendulinum*). Surface textures range from nearly smooth to coarsely pebbled. Within this group are two easily recognizable related spore types.

THE CERNUUM TYPE (*Figs. 7–8*).—Distal ornamentation rugulate to nearly absent, depending upon the species (acetolysis seems to accentuate the ornamentation slightly). The proximal surface is unornamented or faintly undulating, with a raised margo; the triradiate scar is obscured completely in a groove, the groove normally about ⅔ the radius of the spore and not conspicuous. Species examined with spores of this type are: *Lycopodium cernuum, L. convolutum, L. eichleri,* and *L. pendulinum.*

THE CAROLINIANUM TYPE (*Figs. 9–12*).—Distal ornamentation is rugulate to almost reticulate and is bounded at the equator by a more or less well-defined rim (*Fig. 9*). The proximal surface is rugulate to merely wrinkled, or becomes verrucate to verrucate-gemmate. The tetrad scar may or may not be visible in the usually conspicuous groove (less conspicuous in *L. laterale, Fig. 12*), and reaches or almost reaches the margin. The margo is raised and generally prominent, straight-sided to sharply notched, and variously ornamented depending upon the species; it may be almost smooth or may closely match the pattern on the rest of the contact face. Spore variation between species is greater within this type than between spores of the Cernuum Type. Species examined with spores of the Carolinianum Type are: *Lycopodium adpressum, L. alopecuroides, L. carolinianum, L. duidae, L. inundatum,* and *L. laterale.*

THE RETICULATE GROUP

All but two of the remaining species studied may be placed in this broad group, which includes *Diphasium* and *Lycopodium* as defined by Rothmaler (1944). Although basically tetrahedral, spores of some species that have decidedly convex contact faces become subglobose. Spore outline ranges from subtriangular to nearly circular. Distal surfaces are ornamented with high, narrow ridges (muri) that join to form a reticulum. Proximal surfaces are entirely unornamented or partially covered by a reticulum. When present, the proximal reticulum may or may not



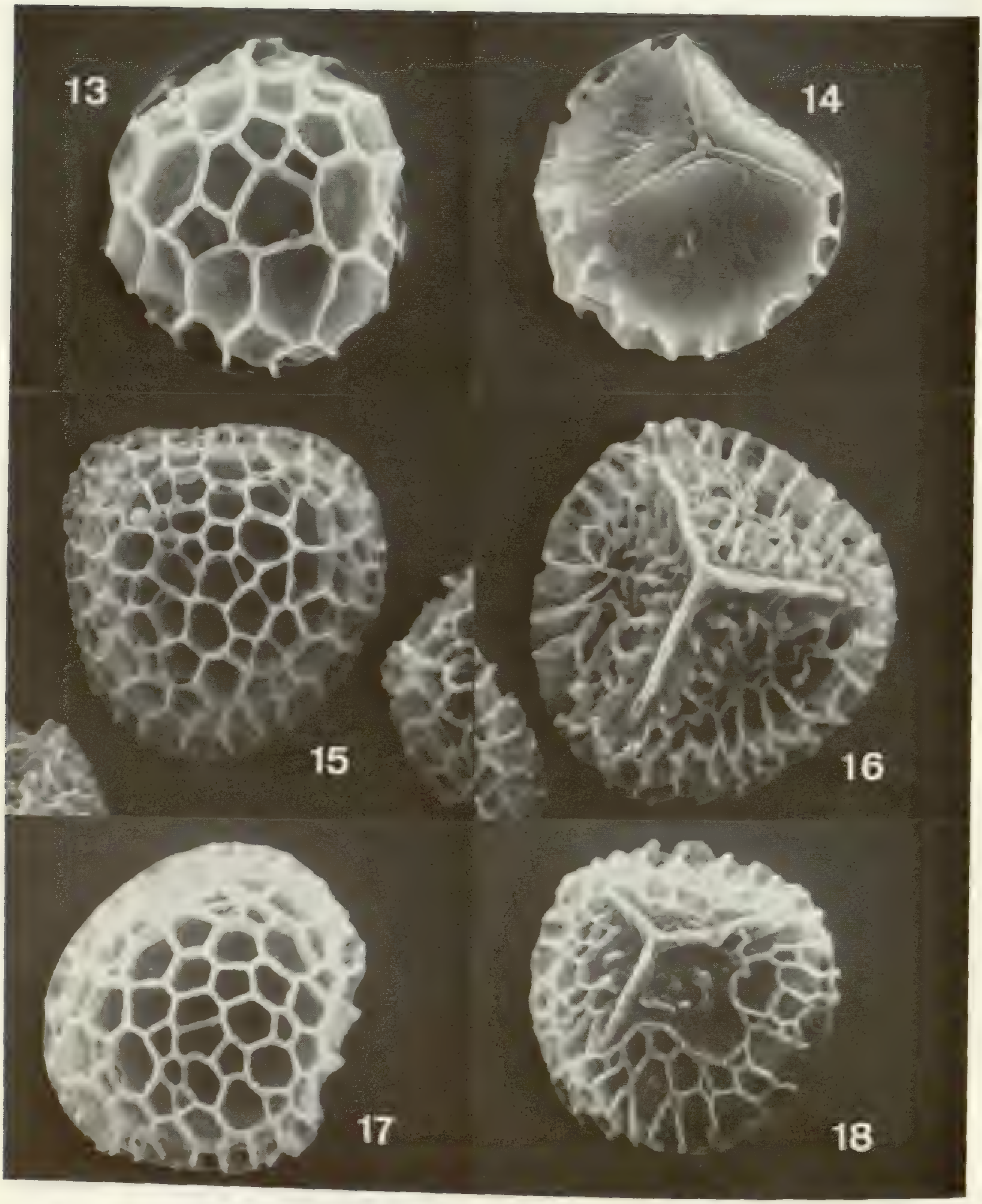
Lycopodium spores. Fig. 7. Distal view of *L. cernuum*, × 1400 (San José, Costa Rica, *Skutch 2217*, GH). Fig. 8. Same, proximal view, × 1400. Fig. 9. Equatorial view of *L. alopecuroides*, × 1280 (Cuba, 9 Sept 1940, *Hodge, Howard & Godfrey*, MASS). Fig. 10. Proximal view of *L. carolinianum*, × 1280 (British Honduras, *O'Neill 8391*, GH). Fig. 11. Same, distal view, × 1280. Fig. 12. Proximal view of *L. laterale*, × 1280 (New Zealand, *Hollaway 324*, MASS).

closely resemble that of the distal surface. In a few species the proximal reticulum has been reduced to scattered free ridges and knobs. Four related spore types may be recognized within the Reticulate Group.

THE SCARIOSUM TYPE (*Figs. 13–14*).—Contact faces are much flattened, giving the spore a somewhat semicircular profile, the distal surface being broadly convex. The distal reticulum is regular with a large, open mesh (larger lacunae measure up to 12 μ in greatest dimension; small lacunae under 4 μ are rare). Muri are 1–1.5 (rarely 2) μ high and only occasionally become bridges through erosion of their sides. Proximal surface is without ornamentation except for slight undulations not visible with light microscopy. The tetrad scar extends ⅔ the radius to nearly reaching the margin, and is situated in and sometimes is partially obscured by a shallow groove. Taxa examined having spores of the Scariosum Type are: *Lycopodium canceris, L. gayanum, L. holtonii, L. jussiaei,* and *L. scariosum.* It is likely that not all these are good species; their status is under investigation.

THE CLAVATUM TYPE (*Figs. 15–18*).—The distal reticulum is more or less regular, the polygons normally complete although on a single spore they may vary greatly in size. Muri on individual spores are relatively uniform in size and thickness, ranging from 2 to 4 μ high, depending upon the species, and normally slightly higher at the equator than near the distal pole. Mural erosion is common on the sides, resulting in windows and bridges. Proximal surfaces in most taxa are at least partially reticulate, the ornamentation approaching the laesurae to a greater extent in some than in others (*Figs. 16, 18*). The proximal reticulum may be more delicate than the distal reticulum (*L. obscurum*) or it may be more irregular and broken (*Fig. 18*), sometimes being so reduced and broken as to no longer form a reticulum (*L. annotinum*). Laesurae are prominent, narrow ridges ranging from 1.5 to 2 μ high and extend from ⅔ the radius to nearly reaching the margin. There is noticeable variation between species as to pattern detail. The following taxa examined have spores of the Clavatum Type: *Lycopodium alpinum, L. annotinum, L. clavatum, L. complanatum, L. contiguum, L. flabelliforme, L. japonicum, L. multispicatum, L. obscurum, L. platyrhizoma, L. sabinifolium, L. sitchense, L. thyoides, L. tristachyum, L. veitchii, L. venustulum, L. vestitum,* and *L. wightianum.*

THE FASTIGIATUM TYPE (*Figs. 19–21*).—The distal reticulum is irregular, both in size and shape of lacunae and in height (up to 2 μ) and thickness of muri. Erosion of muri takes place from all directions, producing numerous incompletely walled polygons, bridges, and lower muri. The reticulum is a finer mesh than in the previous types; a large lacuna in this group measures not more than 5–6 μ across. Reticula extend slightly over the equator and onto the proximal surface, and end rather abruptly at the edge of the contact faces, but without forming a rim or fringe. Contact faces are often slightly concave near the reticulate margin (possibly an artifact produced by drying, but in any case a feature of this type of spore not seen in other types), but they become more convex near the tetrad scar. Laesurae form prominent narrow ridges extending to the edge of the reticulum. The Fastigiatum Type spore was found in the following species examined: *Lycopodium fastigiatum, L. magellanicum, L. paniculatum,* and *L. spurium.*



Lycopodium spores. Fig. 13. Distal view of *L. scariosum*, × 1400 (New Zealand, 14 Mar 1927, *Setchell & Setchell*, UC). Fig. 14. Same, proximal view, × 1400. Fig. 15. Distal view of *L. clavatum*, × 1400 (White Mt. Nat. Forest, New Hampshire, *Wilce 53-70*, MASS). Fig. 16. Same, proximal view, × 1400. Fig. 17. Distal view of *L. complanatum*, × 1400 (Yukon, *Wilce study coll. 78*, DAO). Fig. 18. Same, proximal view, × 1400.

THE VOLUBILE TYPE (*Figs. 22–24*).—The distal reticulum is irregular, with many incomplete polygons. Muri range up to 2.5–3 μ high; erosion produces isolated ridges, pillars, and numerous bridges and windows. The reticulum ends abruptly at the equator. The proximal surface is unornamented except for a delicate rim completely encircling the outer margin of the contact faces. This rim, "frill," or "fringe," as it has been called by Knox (1950) and Harris (1955), measured up to 5 μ high in air-dried material. Behind the rim, and completely hidden by it in apical view, is a slightly concave, unornamented region extending to the equator (*Fig. 22*). The laesurae are prominent, narrow ridges up to 3 μ or 4 μ high that extend to the edge of the proximal rim. *Lycopodium volubile* is the only species known to have this type of spore. It seems more closely related to the Fastigiatum Type than to others of the Reticulate Group.

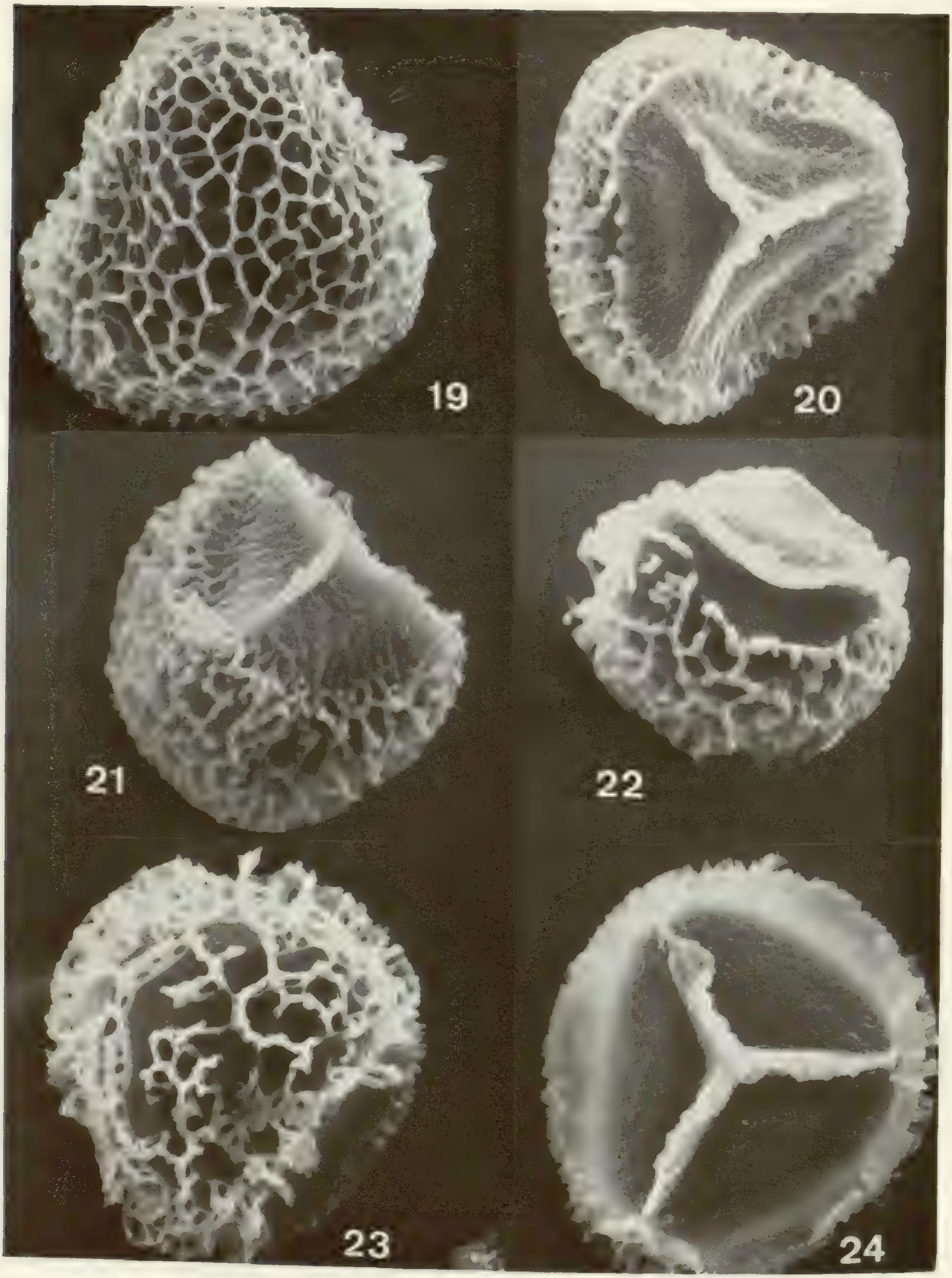
THE BACULATE SPORE

Lycopodium deuterodensum Herter is more widely known as *L. densum* Labill., unfortunately an illegitimate later homonym of *L. densum* Lam. This species is the only lycopod known to have baculate spores (*Figs. 25–27*). Herter (1950) lists *L. riofrioi* Sod. as a closely related species, but material was not available for this study, and its spores are still unexamined.

The spores are, subtriangular in polar view, with the distal portion broadly hemispherical and the contact faces somewhat flattened. The distal surface is covered with baculate projections rather uniformly 2.5–3 μ high and nearly 1 μ thick which are normally only slightly (if at all) thicker at the base, almost always truncate, and only rarely appear spinose. [Knox (1950) describes the spores as "spinose" and Harris (1955) refers to them as "echinulate," although noting the truncate tips. In most cases the tapering is so slight that I feel the term "baculate" most adequately describes the condition.] The projections are generally 3–5 μ distant, and at higher magnifications can be seen to be covered by the same small, rounded bodies that cover the rest of the distal spore surface (*Fig. 27*). The proximal surface is unornamented. Laesurae are prominent as a rounded ridge 1 μ wide and at least 1.5–2 μ high which extends nearly to the margin. Knox (1950) has called attention to the resemblance of spores of *L. deuterodensum* to the microspores of certain species of *Selaginella.*

THE SCABRATE SPORE

This spore type has been observed only in *Lycopodium casuarinoides* Spring (*Figs. 28–30*). Knox (1950) describes and figures the spore of some other taxon under this name, placing it in the group with Phlegmaria Type spores. The spores of this species, however, fit into none of the previously described categories. In apical view they appear subtriangular with very rounded angles and straight to concave sides and contact faces—a bit similar in shape to spores of *L. selago,* although more rounded. Both proximal and distal surfaces are irregularly scabrate; the rounded projections range from 0.25 μ to just under 1 μ, and average 0.5 μ in diameter. The distribution of projections is not uniform. At high magnifications



Lycopodium spores. Fig. 19. Distal view of *L. fastigiatum*, × 1400 (Australia, *Burcham 92*, US). Fig. 20. Same, proximal view, × 1400. Fig. 21. Equatorial view of *L. magellanicum*, × 1400 (Juan Fernandez Isl., *C. & I. Skottsberg 482*, US). Fig. 22. Equatorial view of *L. volubile*, × 1400 (Benguet, Philippines, *Santos*, Bureau Sci. 31776, US). Fig. 23. Distal view of *L. volubile*, × 1400 (Luzon, Philippines, *Sulit*, Phil. Nat. Herb. 5119, GH). Fig. 24. Same, proximal view, × 1400.

these projections are seen to carry numerous, smaller, globose bodies which cover the remainder of the spore as well (*Fig. 28*). These features are present in air-dried material, but are better viewed in acetylated spores. Laesurae are low and narrow, relatively inconspicuous ridges extending nearly to the margin.

DISCUSSION

There can be no doubt that *Lycopodium* is a more heterogeneous genus than are many others; certain natural groupings of species have been recognized by nearly every systematist working with the group. But botanists have failed to agree on how the group should be further subdivided—or even if it should be.

Both Knox (1950) and Harris (1955) felt that none of the various systems advanced for *Lycopodium* by other authors adequately fit the data provided by spore morphology, although certain groupings found more support than others. Knox, for instance, says that ". . . it should be admitted that Pritzel's division into two sub-genera, based on spore characters, is more easily maintained than the division into six sub-genera [a reference to Herter's (1909) system adopted by Walton and Alston in "Manual of Pteridology" (1939)], since the spores fall into two major well-defined groups, the pitted and the reticulate."

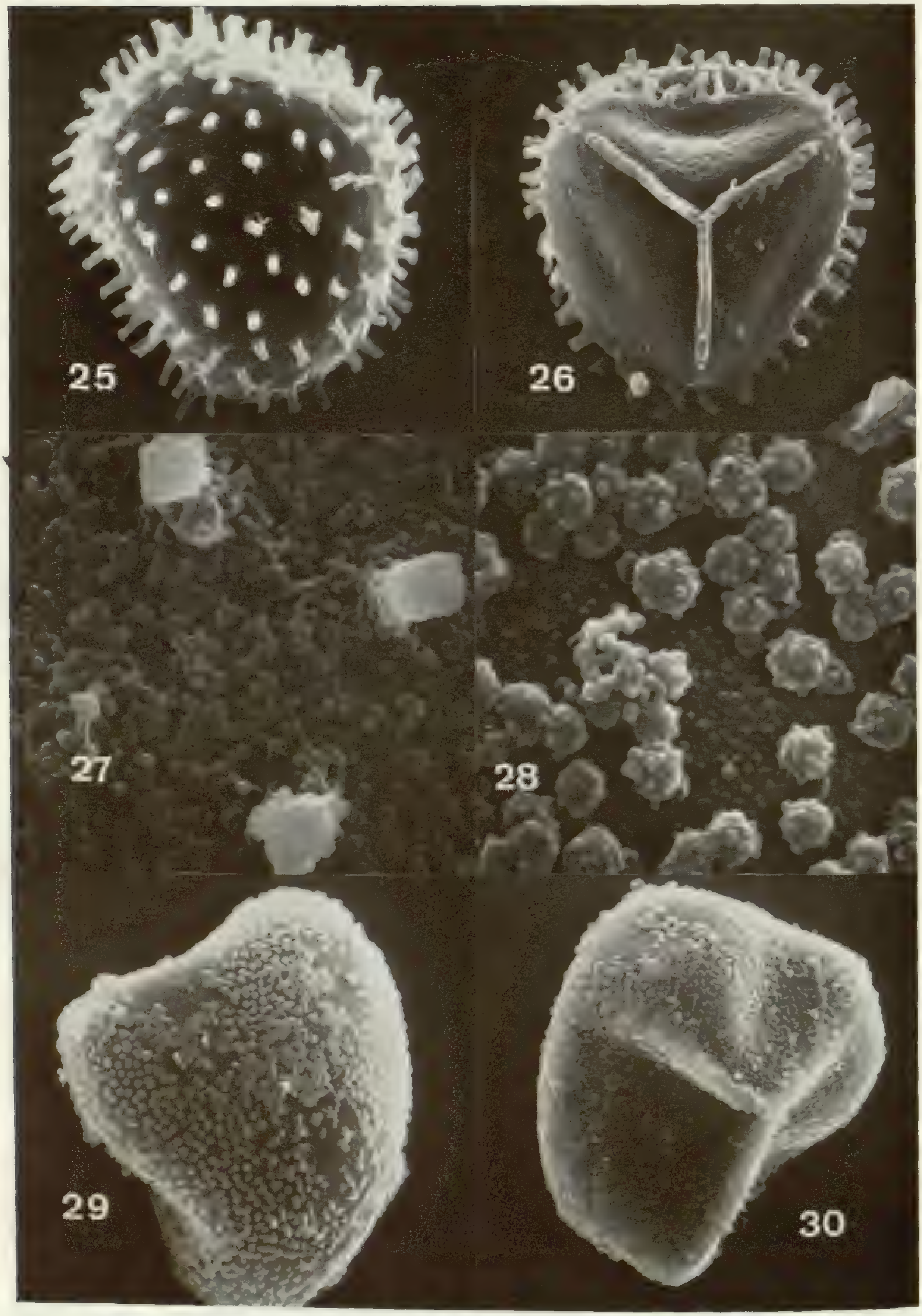
Leaving aside for the moment the baculate spores of *Lycopodium deuterodensum* and the scabrate spores of *L. casuarinoides,* in my view there are not two, but three major well-defined groups, recognizing the rugulate as distinct from the reticulate, a separation Knox does not make. If these groups are taxonomically meaningful, then some correlation with other consistent group characteristics should be noted.

Holloway (1919) made this correlation, except for the spore information. In his detailed study of the New Zealand species of *Lycopodium,* he divided them into sections *Selago, Phlegmaria, Inundata, Cernua,* and *Clavata.* He compared five features recognized as important: (1) growth habit and external form, (2) stem anatomy, (3) character of the fertile region, (4) form and structure of the prothallus, and (5) form of the young plantlet. It is not necessary to repeat the details of his findings; those interested will find Holloway's own account worth careful reading.

For ease of comparison, Holloway combined his discussion of those sections he found most similar in total character. He recognized that sections *Selago* and *Phlegmaria* are closely related, that sections *Inundata* and *Cernua* are a second natural grouping, and that section *Clavata* stands by itself. This grouping of sections conforms exactly with the three large spore groups, showing the expected correlation between spore pattern and overall morphology.

The spore groups also fit with Rothmaler's (1944) treatment of the genera *Huperzia, Lepidotis* and *Lycopodium,* but not with his fourth genus, *Diphasium.* Nor does *Diphasium* distinguish itself from *Lycopodium* on other grounds when Holloway's (1919) study of *Lycopodium scariosum* and Wilce's (1965) treatment of section *Complanata* are considered.

Rothmaler based his separation of *Diphasium* from *Lycopodium* purely on prothallial shape and the bilateral nature of the branchlets in *Diphasium.* Löve and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Löve (1958) reinforce Rothmaler by calling attention to the lower chromosome number in *Diphasium,* but weaken his case by suggesting that prothallial shape may have been taxonomically overvalued.

Lang (1899), Holloway (1919), Bower (1935), Löve and Löve (1958), and Wilce (1965), all believe that prothallial shape is not significant. This can hardly be doubted now that experimental studies have shown the differences to be mainly environmentally controlled (Freeberg & Wetmore, 1957; Freeberg, 1962).

Bilateral branches are not restricted to *Diphasium,* nor are all *Diphasium* taxa flat-branched, and so this character does not separate *Diphasium* from *Lycopodium.* Further, numerous species throughout *Lycopodium* show a bilateral leaf orientation, which requires only a broadening of the lateral leaf bases to produce the flat-branched condition. So minor a vegetative adjustment seems an unlikely generic character.

Chromosome number is of possible generic significance, but recent investigations (Wilce, unpubl.) place the haploid number of *L. jussiaei* (type species of *Diphasium*) at ca 34–36, putting it close to that of *L. clavatum* ($n = 34$), rather than to *L. complanatum* ($n = 23$). If a generic separation is to be made based on chromosome number, the Complanatum Group must stand alone, not as *Diphasium.* I cannot consider a difference in chromosome number sufficient basis for any genus, however, and there is little additional support.

There are, then, three major non-arbitrary groups (using "arbitrary" and "non-arbitrary" in the sense of Simpson, 1951) within *Lycopodium.* The basic continuity within these groups and the discontinuity which separates them can be expected to receive additional confirmation as more systematic data come in from the fields of ecology, biosystematics, cytogenetics and biochemistry. I do not believe we should call these three groups genera.

Many authors have discussed the problem of higher taxonomic categories. Mayr (1942) summarizes his view this way:

> The genus is based on the fact that the species are not evenly distinct from one another, but are arranged in smaller or larger groups, separated by smaller or larger gaps. The genus is therefore based on a natural phenomenon. How many of such groups are to be included in one genus and how the genus should be delimited from other genera are matters of convenience to be left to the judgment of the individual systematist. The genus of the systematist is his own artificial creation and not a natural unit. The same is true for the higher categories above the genus (family, order, and so forth); the groups on which they are based may be natural but their terminologies and *comparative values are not* [italics mine].

Taking this view, a systematist is not obligated to divide a genus into several genera, even though he can make a morphological case for doing so. In fact, if dividing a genus does not result in a more manageable system, he should resist

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Lycopodium spores. Fig. 25. Distal view of *L. deuterodensum,* × 1400 (Mt. Koghi, New Caledonia, Oct 1906, *Franc,* GH). Fig. 26. Same, proximal view, × 1400. Fig. 27. Same, acetylated, × 8550. Fig. 28. Distal surface, acetylated spore of *L. casuarinoides,* × 12,800 (Kwangtung, China, *Tsang 20677,* GH). Fig. 29. Same, air dried spore, distal toward equatorial view, × 1400. Fig. 30. Same, proximal view, × 1400.

such a division. In such a situation, recognition of the natural species groupings is sufficient to satisfy the goals of modern systematics.

The case for dividing *Lycopodium* into splinter genera is not strong enough. The discontinuities between the species groups are not as great as some authors have suggested. To leave the genus intact is not a move that obscures the phylogenetic relationships between its members—these are approachable as it is. To divide the genus certainly adds nothing to our understanding of it. Finally, to leave *Lycopodium* whole is to maintain a genus that anyone can recognize at a glance, an attribute not to be discarded lightly.

What status, if not generic, should be given these natural species groups? Mayr (1942), with zoological bias, regards the subgeneric category as unnecessary, preferring an informal recognition of species groups without nomenclatural status. I feel that in botanical classification the subgeneric category is of definite value. Formal recognition of these groups as subgenera of *Lycopodium* also may help to satisfy "splitters," whereas informal status might not.

None of the earlier formal subdivisions of *Lycopodium* quite fits our present knowledge. Holloway's (1919) informal groupings, as noted earlier, are consistent with the biological facts. The scheme presented below merely assigns available subgeneric names to those groups, and modifies his subgroups (sections) only slightly. Some sections have no names available at any rank; these require Latin diagnoses, which, with their formal naming, is deferred for a later paper in which the subgenera and sections will be treated in greater detail. At this time, however, informal recognition is desirable. The subdivision of *Lycopodium* I adopt is:

Subgenus *Urostachys* Pritzel (1900)
  Section 1. *Selago* Dill. ex Pritzel (1900)
  Section 2. *Phlegmaria* (Baker) Pritzel (1900)
Subgenus *Lepidotis* (Palisot) Baker (1887)
  Section 1. *Cernua* (Baker) Pritzel (1900)
  Section 2. *Inundata* (Baker) Pritzel (1900)
  Section 3. *Lateralia* Baker (1887)
Subgenus *Lycopodium*
  Section 1. *Lycopodium*
  Section 2. *Complanata* Victorin (1925)
  Sections 3–7 not yet formally named

Sections 3–7 represent the following elements: the Scariosum Group, the Fastigiatum Group, the Volubile Group (possibly monotypic), *Lycopodium deuterodensum,* and *L. casuarinoides.*

The sections containing the latter two species are placed in the subgenus *Lycopodium* only tentatively. Closer study of *L. deuterodensum* will probably confirm its position here. Its striking, baculate spores could be derived from the reticulate type; in other important characters it conforms to the subgenus. The case is less clear for *L. casuarinoides.* Its spores do not closely resemble any others within the subgenus, and although its stele is of the banded type, it differs from the other banded steles of the genus. It may prove to be secondarily derived from the "mixed" stele type. Chromosome number and gametophyte type, so far as I know, are

unknown for this species. As the species becomes better known, the section may require elevation to subgeneric status.

This revised classification for *Lycopodium* is offered in earnest hope that it will satisfy botanists' need to recognize nomenclaturally the biological discontinuities within this ancient group of plants. At the same time, it reaffirms the view that *Lycopodium* represents a relatively non-arbitrary clustering of related elements that do not require, and should not receive, generic recognition.

LITERATURE CITED

BAKER, J. G. 1887. Handbook of the fern-allies. London.

BOIVIN, B. 1950. The problem of generic segregates in the form-genus Lycopodium. Amer. Fern J. **40:** 32–41.

BOWER, F. O. 1935. Primitive land plants also known as the archegoniatae. London.

FAEGRI, K. and J. IVERSEN. 1950. Textbook of modern pollen analysis. Munksgaard, Copenhagen.

FREEBERG, J. A. 1962. Lycopodium prothalli and their endophytic fungi as studied in vitro. Amer. J. Bot. **49:** 530–535.

————, and R. H. WETMORE. 1957. Gametophytes of Lycopodium as grown in vitro. Phytomorph. **7:** 204–216.

HARRIS, W. F. 1955. A manual of the spores of New Zealand Pteridophyta. N. Z. Dept. Sci. Indust. Research Bull. 116. Wellington.

HERTER, W. 1909. Beiträge zur Kenntnis der Gattung Lycopodium. Bot. Jahrb. Engler **43:** Beibl. **98:** 1–31.

————. 1950. Systema Lycopodiorum. Estudios Botánicos en la Region Uroguaya XXI. Montevideo.

HOLLOWAY, J. E. 1919. Studies in the New Zealand species of the genus Lycopodium III. The plasticity of the species. Trans. N. Z. Inst. **51:** 161–261.

KNOX, E. M. 1950. The spores of Lycopodium, Phylloglossum, Selaginella and Isoëtes and their value in the study of microfossils of Paleozoic age. Trans. Bot. Soc. Edin. **35:** 209–357.

LANG, W. H. 1899. The prothallus of Lycopodium clavatum L. Ann. Bot. **13:** 279–317.

LÖVE, A. and D. LÖVE. 1958. Cytotaxonomy and classification of lycopods. The Nucleus **1:** 1–10.

MAYR, E. 1942. Systematics and the origin of species, Chap. 10. The higher categories and evolution. pp. 275–298. Columbia University Press, New York.

PRITZEL, E. 1900. Lycopodiaceae *in* A. Engler & K. Prantl, Nat. Pflanz. **1**(4): 563–606. W. Engelmann, Leipzig.

ROTHMALER, W. 1944. Pteridophyten-studien. I. Rep. Sp. Nov. Fedde **54:** 55–82.

SIMPSON, G. G. 1951. The species concept. Evolution **5:** 285–298.

WALTON, J. and A. H. G. ALSTON. Chapter 17, Lycopodiinae *in* F. Verdoorn, ed. Manual of Pteridology. M. Nijhoff, The Hague.

VICTORIN, Fr. M. 1925. Les Lycopodinées du Quebec et leurs formes mineures. Contrib. Lab. Bot. Univ. Montréal 3. Montréal.

WILCE, J. H. 1965. Section Complanata of the genus Lycopodium. Nova Hedw. Beih. 19. J. Cramer, Weinheim.

WILSON, L. R. 1934. The spores of the genus Lycopodium in the United States and Canada. Rhodora **36:** 13–19.

The Nomenclature of Isoëtes echinospora and Isoëtes muricata

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Several errors commonly are present in the author citations of a taxon which is treated as a variety under either *Isoëtes echinospora* Dur. or *I. muricata* Dur. One of the early names for the American plants of this group was *I. braunii* Dur. (Bull. Soc. Bot. France **11:** 101. 1864), but this is a later homonym of *I. braunii* Unger published in 1850 for a fossil European species (Reed, 1945). Engelmann (1867), apparently unaware that *I. braunii* Dur. was a later homonym, "transferred" it to varietal status under *I. echinospora*. The use of the epithet *braunii* is legitimate, but it must be treated as a new name, and not as a transfer according to the Note under Article 72 of the Code. The correct citation is, therefore, *I. echinospora* Dur. var. *braunii* Engelm., not var. *braunii* (Dur.) Engelm. as used by Morton (1952) and others. Reed's (1945) use of the epithet *braunii* as a variety of *I. muricata* Dur. should, consequently, be var. *braunii* (Engelm.) Reed, not var. *braunii* (Dur.) Reed.

TABLE 1. CORRECT AUTHOR CITATION FOR CERTAIN EPITHETS IN THE *ISOËTES ECHINOSPORA–MURICATA* COMPLEX

Taxonomy adopted	*American plants*	*European plants*
Two species without subspecies	I. muricata Dur. var. muricata var. braunii (Engelm.) Reed	I. echinospora Dur. var. echinospora
One species without subspecies	I. echinospora Dur. var. muricata (Dur.) Engelm. var. braunii Engelm.	I. echinospora Dur. var. echinospora
One species with subspecies	I. echinospora Dur. subsp. muricata (Dur.) Löve & Löve var. muricata var. braunii Engelm.	I. echinospora Dur. subsp. echinospora var. echinospora

Löve and Löve (1961) treated *I. echinospora* as consisting of two subspecies, ssp. *echinospora* and ssp. *muricata* (see also Löve, 1962). The citation of the epithet *braunii* as a variety of ssp. *muricata,* however, should continue to be var. *braunii* Engelm., not var. *braunii* (Dur.) Löve & Löve, according to Article 47 of the Code. No transfer was made by Löve and Löve. For nomenclatural purposes, the epithet at each of the several subspecific ranks is referable directly to the species, whether or not an epithet at a rank between the species and the lower category is interposed (see Art. 26, 1972 Code).

The use of *I. setacea* Lam. for *I. echinospora* by Cronquist (1969) was due to an unfortunate error (see Morton, 1970), and the use of *I. tenella* Desv. for *I. echinospora* by Fuchs (1962) has also been challenged (Morton, 1970).

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Correct author citations are summarized in *Table 1*. Other species, subspecies, and varieties are often recognized, but their names present no difficulties.

I would like to acknowledge the assistance of J. R. and C. G. Reeder on this problem, especially their critical reading of the manuscript.

LITERATURE CITED

CRONQUIST, A. 1969. Isoëtaceae, pp. 34–38, *in* C. L. Hitchcock, et al., Vascular Plants of the Pacific Northwest, Part 1. Univ. of Washington Press, Seattle. 914 pp.

ENGELMANN, G. 1867. Isoëtes, pp. 675-677, *in* A. Gray, Manual of the Botany of the Northern United States, 5th ed. Ivison, Blakeman, Taylor & Co., New York and Chicago. 703 pp.

FUCHS, H. P. 1962. Nomenklatur, Taxonomie und Systematik der Gattung Isoëtes Linnaeus in geschichtlicher Entwicklung. Nova Hedw. Beih. **3:** 1–104.

LÖVE, A. 1962. Cytotaxonomy of the Isoëtes echinospora complex. Amer. Fern J. **52:** 113–123.

————, and D. LÖVE. 1961. Some nomenclatural changes in the European flora. II. Subspecific categories. Bot. Notiser **114:** 48–56.

MORTON, C. V. 1952. Isoëtaceae, pp. 9–12, *in* H. A. Gleason, The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada, Vol. 1. New York Botanical Garden, New York. lxxv + 482 pp.

————. 1970. Recent fern literature. Amer. Fern J. **60:** 37.

REED, C. F. 1945. Some nomenclatural changes in the genus Isoëtes. Amer. Fern J. **35:** 77–86.

Conrad V. Morton

Conrad V. Morton, an Honorary Member of the American Fern Society and a member of the Society since 1940, died suddenly of a heart attack at his home on Saturday, July 29. Although he had been in somewhat precarious health since 1961, he had kept to a full schedule of work and travel, and carried on a very large correspondence with professional and amateur botanists all over the world. Mr. Morton was an Associate Editor of the JOURNAL from 1941 to 1947 and from 1962 to the present. From 1948 to 1961 he was the Editor-in-Chief. His contributions to the JOURNAL and to the Society in general have been of inestimable value. A special memorial issue of the JOURNAL is planned for the coming year.—*D.B.L.*

Observations on the Occurrence of the Prothallia of *Lycopodium inundatum*

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In the study of pteridophytes, the discovery of sexual plants is generally unusual. This is due in part to the small size of the gametophytes and in part to their commonly concealed habit. In the Lycopodiaceae alone, only 10% of the nearly 500 species have known gametophytes (Bierhorst, 1971). Discovering prothallia of pteridophytes under natural conditions is one of the most challenging problems of field botany.

In this paper I wish to report the first record of *Lycopodium inundatum* L. gametophytes for North America and to discuss their characteristics and the circumstances of their discovery.

The gametophytes of the Lycopodiaceae have interested botanists for almost a hundred years since the first discovery of naturally occurring gametophytes (Fankhouser, 1873). Our understanding of these plants, however, has been greatly hindered by the rarity of collections. The most important contributions to our knowledge were all carried out well over 50 years ago by only a few notable workers. They established the taxonomic distribution of the types of gametophytes and also the major stages in the development of the gametophyte and embryo.

Treub (1884; 1886a,b; 1888a,b; 1890a,b,c) in Java described the gametophyte and embryo of *L. cernuum* L. and several other tropical species. Goebel (1887) found and described the gametophyte of *L. inundatum* L. in Europe. This is the only time the gametophyte of this species has ever been reported, as far as I have been able to determine. Probably the best known work on the prothalli of the Lycopodiaceae is that of Bruchmann, who essentially laid the foundations for the systematic study of these plants. It was he who first described (1885, 1898, 1908, 1910) in detail the gametophytes of the temperate species *L. annotinum* L., *L. clavatum* L., *L. complanatum* L. (which may actually have been *L. tristachyum* Pursh according to Wilce, 1965), and *L. selago* L. Bruchmann also succeeded in growing the prothalli of *L. annotinum, L. clavatum,* and *L. selago* from spores, which required in some cases 6–7 years to germinate and 12–15 years to mature. An excellent review of the early attempts to germinate the spores of *Lycopodium* species was made by Chamberlain (1917). Freeberg and Wetmore (1958), in their study of the culture of *Lycopodium* gametophytes *in vitro,* have summarized in greater detail than is done here the contributions of Bruchmann, Treub, and Goebel.

Bruchmann (1898) divided the gametophytes of *Lycopodium* into five categories based on habit and anatomical organization. Three of these types are sub-

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[1] I wish to express my sincere thanks to Dr. Warren H. Wagner, Jr., for his continual encouragement, help, and interest in this endeavor; also to Dr. Edward G. Voss and Mr. T. Lawrence Mellichamp for their help in identifying the associates; and to Mr. Michael R. Mesler for his assistance in both the field and laboratory during this work.

terranean and characteristic of most terrestrial members of the genus. Another is epiphytic in bark humus and is characteristic of many tropical species. The last is green, superficial on the soil, and is typical of the bog clubmosses. The third type is also found in the gametophyte of *Phylloglossum,* a closely related genus.

Gametophytes of the green, superficial type have been illustrated for *L. alopecuroides* L. (Eames, 1942), *L. cernuum* L. (Treub, 1884), *L. inundatum* L. (Goebel, 1887), *L. laterale* R. Brown (Chamberlain, 1917), *L. ramulosum* Kirk (Holloway, 1920), and *L. salakense* Treub (Treub, 1888a).

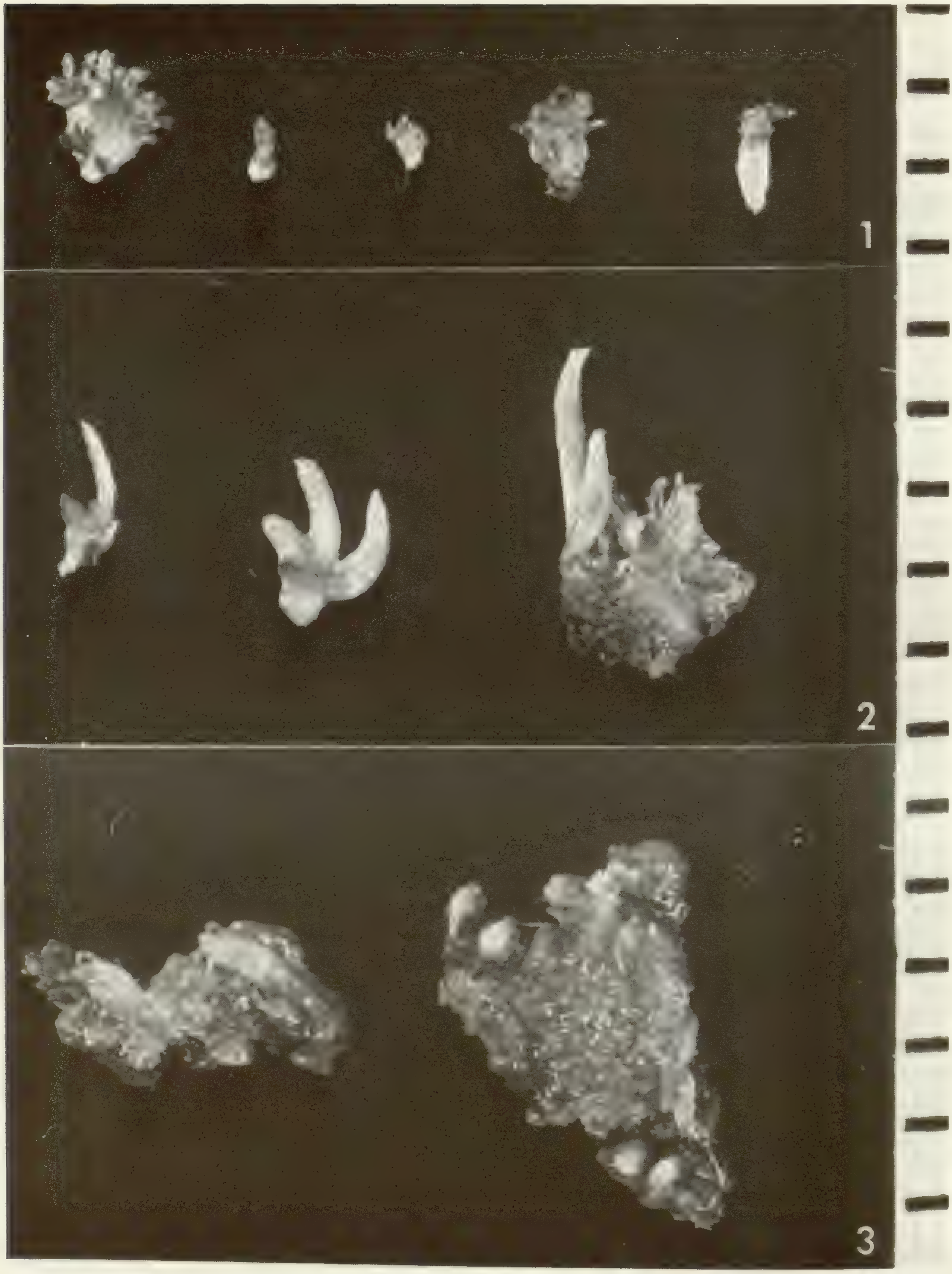
I sought gametophytic material for purposes of confirming earlier reports, as well as to enable additional studies involving growth and development of the gametophyte and the embryogeny of the young sporophyte. *Lycopodium inundatum* is the most abundant of the bog clubmosses in Michigan. It occurs in numerous localities throughout much of the state. The most productive of these have been the many borrow pits which flank new highways and are the source of fill dirt. These often form sandy, damp depressions which are ideal for the growth of these plants. Gametophytes of *L. inundatum* have been found in two localities, one in Midland County in the central part of the lower peninsula of Michigan and the other some 130 miles distant in Van Buren County in the southwestern part of the lower peninsula. Mature sporophytes were present in large numbers and were seen growing approximately one meter from the gametophytes in both localities.[2] However, in the Midland County site large colonies of sporophytes were no nearer than 10 meters. Both sites were visited in the late summer and early fall. In addition, the Midland County site was visited in the early spring.

The following plants were noted as associates in the Midland County locality: *Equisetum arvense, Gerardia tenuifolia, Lycopus uniflorus, Salix rigida, Salix alba* × *fragilis, Solidago graminifolia, Typha angustifolia,* and *Viola lanceolata.* The Cat-tail was the most conspicuous element in the immediate area. The gametophytes were confined to the areas between the tufts of Cat-tail. These surfaces were typically open with little other vegetation present. The microhabitat presented a minutely rough terrain. Numerous tiny hill-and-valley situations were present with the gametophytes more plentiful in the valleys and on the slopes than on the more exposed crests.

At the Van Buren County site, the location of the gametophytes within the microhabitat was essentially the same as at the Midland County locality. Here, however, the gametophytes were confined to a raised, sandy region along a small stream. Mature sporophytes were present along both banks of the stream, but not on the sand bar where the gametophytes were found. The sand bar was covered by a more or less open growth of grasses and sedges with bare ground between the tufts. The sandy soil was moist probably because of the proximity of the stream.

Locating the gametophytes is a difficult process. Habitats were first visited where mature colonies of sporophytes were known. Within these, likely areas were selected

[2] In the Van Buren County locality some of the gametophytes found may belong to a closely related variety or species, the sporophyte of which has been detected at this locality, growing with typical *L. inundatum,* and which will be reported in detail in the near future.



Lycopodium inundatum. Fig. 1. Young gametophytes. Fig. 2. Gametophytes with young sporophytes attached. Fig. 3. Massive gametophytes with several attached sporophytes. Scale in millimeters.

which possessed numerous, small (up to 1 cm long) sporophytes. If closer examination of these areas with a hand-lens revealed any gametophytes, soil turfs approximately 20 cm^2 were removed and transported to the laboratory where they were carefully examined with a dissecting microscope. Utilizing this technique, I discovered over 100 gametophytes, many of them with attached young sporophytes, from the Midland County site, and about 25 from the Van Buren County site.

Within the collections there is considerable variation in the size of individual gametophytes, with no break in the range of sizes. Some are quite massive and bear as many as five young sporophytes; others are much smaller and appear to lack sex organs.

There was a great variety of ecological situations in the microhabitats with respect to light, moisture, topographic, and edaphic factors. Spores doubtless fall into most of these different ecological sites. As some of these are more suitable for germination than others, variation with respect to time of spore germination is likely. Similarly, gametophyte growth may be expected to vary according to micro-environmental factors. Both factors give rise to size variation in individual plants.

The Midland County site was visited in early April to determine whether gametophytes survived winter conditions. Previous reports on this point were unclear; the undefined term "short-lived" frequently has been applied to the gametophytes. The following observations show that some prothallia survive winter in a mature state and suggest that survival for more than one season is possible. The locality at the time of our visit was covered with about 5 cm of ice; several centimeters of snow covered most of the area. Up to 8 cm of water was observed under the ice. The ground was not frozen, and soil turfs were removed easily. The only real difficulty was choosing the correct point to cut through the ice. Soil turfs taken from the site revealed several gametophytes of various sizes. The largest of these was 2.2 mm long by 0.7 mm diameter and is quite comparable to those of *Fig. 1*. The gametophytes appeared to be entirely healthy judging from turgidity and green color.

An additional factor affecting gametophyte growth is the endophytic fungus. Freeberg (1962), in his study of the endophyte-prothallus relationship *in vitro*, points out that on starch media he was able to obtain greater prothallial growth with an endophytic fungus present than in those prothallia cultured in its absence. He also states that the fungus assists in this growth only when it has actually entered the prothallus. In earlier work, de Bary (1858) germinated the spores of *L. inundatum* and grew them to a maximum of 11 cells. They would grow no larger in culture. Treub (1884) germinated the spores of *L. cernuum* and grew gametophytes up to 10 cells; he asserted that invasion by the endophytic fungus was necessary to insure further development.

It thus seems probable that a combination of factors such as variation in the time of germination of spores, variation in the growth rate of individual gametophytes, variation in the time of encounter with an appropriate endophyte, and overwintering could all lead to variation in the size of individual gametophytes collected at any one time.

The gametophytes themselves are relatively inconspicuous; the largest rarely exceed 5 mm in diameter. Usually the gametophyte resembles a small, upright cylinder partially embedded in the soil with a somewhat expanded aerial portion (*Fig. 1*). The distal expansion is covered by few to many planate lobes one to several cells thick, which impart a bushy appearance to the larger specimens. The sex organs are situated near or at the bases of these lobes. The lower region of the gametophytes is invested with numerous, non-septate rhizoids. The endophytic fungus is confined to this basal region in healthy gametophytes. In necrosing prothallia the fungus assumes a much greater dimension in the affected regions and may eventually completely overrun the gametophyte.

Fig. 4. Longitudinal section of the archegonium of *Lycopodium inundatum* through its axis; n = neck cell.

Young sporophytes are attached peripherally to the prothallus; the size of prothallia with developing sporophytes varies tremendously (*Figs. 2* and *3*). Gametophytes with attached sporophytes appeared progressively more necrotic with increasing size of the sporophyte. Gametophytes without visible, attached sporophytes almost invariably appeared healthy. This suggests that one factor leading to gametophyte death may simply be fertilization and consequent embryo development.

In addition, gametophytes were sectioned by paraffin technique and photomicrographs were made. In the development of the archegonia of *L. inundatum,* relatively few tiers of neck cells are produced. The specimens seen so far show only three tiers, but this may not be the maximum. However, all but the inner tier are sloughed off when, or soon after, the egg matures. Numerous archegonia

with presumably unfertilized eggs possess only a single tier of neck cells (*Fig. 4*). Old archegonia associated with young embryos often show the single tier of neck cells if embryo development has not yet obliterated the essential features. These neck cells appear to have slightly thickened walls, compared with adjacent cells. A similar situation apparently occurs in *L. cernuum*, judging from the illustrations of Treub (1884). Both of these situations appear to be analogous to at least one of the conditions that is seen in the development of archegonia in *Psilotum* (Bierhorst, 1954).

LITERATURE CITED

BIERHORST, D. W. 1954. The gametangia and embryo of Psilotum nudum. Amer. J. Bot. **41:** 274–281.

———. 1971. Morphology of Vascular Plants. Macmillan, New York.

BRUCHMANN, H. 1885. Das prothallium von Lycopodium. Bot. Centralbl. **21:** 23–28.

———. 1898. Über die Prothallien und die Keimpflanzen mehrerer europäischen Lycopodien. Gotha.

———. 1908. Das Prothallium von Lycopodium complanatum L. Bot. Zeit. **66:** 169–181.

———. 1910. Die Keimung der Sporen und die Entwicklung der Prothallien von Lycopodium clavatum L., L. annotinum L. und L. selago L. Flora **101:** 220–267.

CHAMBERLAIN, C. J. 1917. Prothallia and sporelings of three New Zealand species of Lycopodium. Bot. Gaz. **63:** 51–65.

DE BARY, A. 1858. Sur la germination des Lycopodes. Ann. Sci. Nat. Bot., IV, **9:** 30–35.

EAMES, A. J. 1942. Illustrations of some Lycopodium gametophytes. Amer. Fern J. **32:** 1–12.

FANKHAUSER, J. 1873. Ueber den Vorkeim von Lycopodium. Bot. Zeit. **31:** 1–6.

FREEBERG, J. A. 1962. Lycopodium prothalli and their endophytic fungi as studied in vitro. Amer. J. Bot. **49:** 530–535.

———, and R. H. WETMORE. 1958 (dated 1957). Gametophytes of Lycopodium as grown in vitro. Phytomorphology **7:** 204–217.

GOEBEL, K. 1887. Ueber Prothallien und Keimpflanzen von Lycopodium inundatum. Bot. Zeit. **45:** 161–168, 177–190.

HOLLOWAY, J. E. 1920. Studies in the New Zealand species of the genus Lycopodium. Part IV. The structure of the prothallus in five species. Trans. New Zeal. Inst. **52:** 193–239.

TREUB, M. 1884. Études sur les Lycopodiacées. I. Le prothalle du Lycopodium cernuum L. Ann. Jard. Bot. Buitenzorg **4:** 107–138.

———. 1866a. Études sur les Lycopodiacées. II. Le prothalle du Lycopodium phlegmaria L. Ann. Jard. Bot. Buitenzorg **5:** 87–114.

———. 1886b. Études sur les Lycopodiacées. III. Le developpement de l'embryon chez le Lycopodium phlegmaria L. Ann. Jard. Bot. Buitenzorg **5:** 115–139.

———. 1888a. Études sur les Lycopodiacées. IV. Le prothalle du Lycopodium salakense. Ann. Jard. Bot. Buitenzorg **7:** 141–146.

———. 1888b. Études sur les Lycopodiacées. V. Les prothalles du Lycopodium carinatum, nummularifolium et Hippuris. Ann. Jard. Bot. Buitenzorg **7:** 146–150.

———. 1890a. Études sur les Lycopodiacées. VI. L'embryon et la plantule du Lycopodium cernuum L. Ann. Jard. Bot. Buitenzorg **8:** 1–15.

———. 1890b. Études sur les Lycopodiacées. VII. Les tubercules radicaux du Lycopodium cernuum. Ann. Jard. Bot. Buitenzorg **8:** 15–23.

———. 1890c. Études sur les Lycopodiacées. VIII. Considerations théoriques. Ann. Jard. Bot. Buitenzorg **8:** 23–34.

WILCE, J. H. 1965. Section Complanata of the genus Lycopodium. Nova Hedw. Beih. 19. J. Cramer, Weinheim.

Morphology of Hypodematium crenatum (Forsk.) Kuhn: Comments on a Recent Paper

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Some observations dealing with cytomorphology of *Hypodematium crenatum* and phylogenetic relationships of the genus were published a few years ago by Mehra and Loyal (1956) and by Loyal (1960). Japanese material of this species was studied by Hayata (1927) and Iwatsuki (1964). Nayar and Bajpai (1970) have pointed out some "discrepancies" in the observational data published both from this laboratory and also by Iwatsuki. In the following paragraphs comments will be made upon the "discrepancies" noted by Nayar and Bajpai in the papers referred to above.

SYMMETRY OF THE SHOOT AND PHYLLOTAXY.—The shoot and its vascular system, as we recorded, show dorsiventral symmetry. In regard to phyllotaxy it was reported: "the fronds are borne together on the dorsal side. The insertions tend to form diagonal as well as longitudinal rows without any regularity." Nayar and Bajpai quote Iwatsuki (1964) as saying, "two alternating rows" of leaf gaps occur in the Japanese material. Nayar and Bajpai have made no mention of the arrangement of leaves in their morphological description of the rhizome. However, on the basis of the position of leaf gaps in the stelar system, the only arrangement in this fern inferred by them is "three irregular rows" of leaves. The "discrepancy" they noted in our and Iwatsuki's descriptions in fact represents variations of rhizomes of different ages collected from rock-crevices (*Fig. 1*). The variations observed in a given sample may be attributed to the age factor, as well as to the shape and size of the rock crevices. The latter, extrinsic factor also imposes a wide range of variation not only on the form of the basal, swollen part of the stipe but also on the distribution of mechanical cells in its ground tissue (*Fig. 3*). Both these attributes of the stipe are usually constant in ferns growing in uniform, non-restrictive substrata. Secondly, there is abundant evidence available in the literature to show that variations in leaf number and their arrangement in different individuals of the same species or different parts of the same shoot reflect organogenic activity of the perennial meristem in response to factors operating within the meristem and its environments. Bierhorst (1971) has shown in *Equisetum* that the production of an abnormally large leaf in a whorl initiates spiral phyllotaxy in some shoots, in contrast to the whorled arrangement generally known in the Equisetales. Thirdly, at no stage did we question the spiral phyllotaxy in this fern. Our use of the expression, "irregular rows" (or "two alternate rows" by Iwatsuki) is quite appropriate since the spiral phyllotaxy in dorsiventral shoots (e.g., of the heterophyllous species of *Selaginella*) has been described in morphological texts as being in rows.

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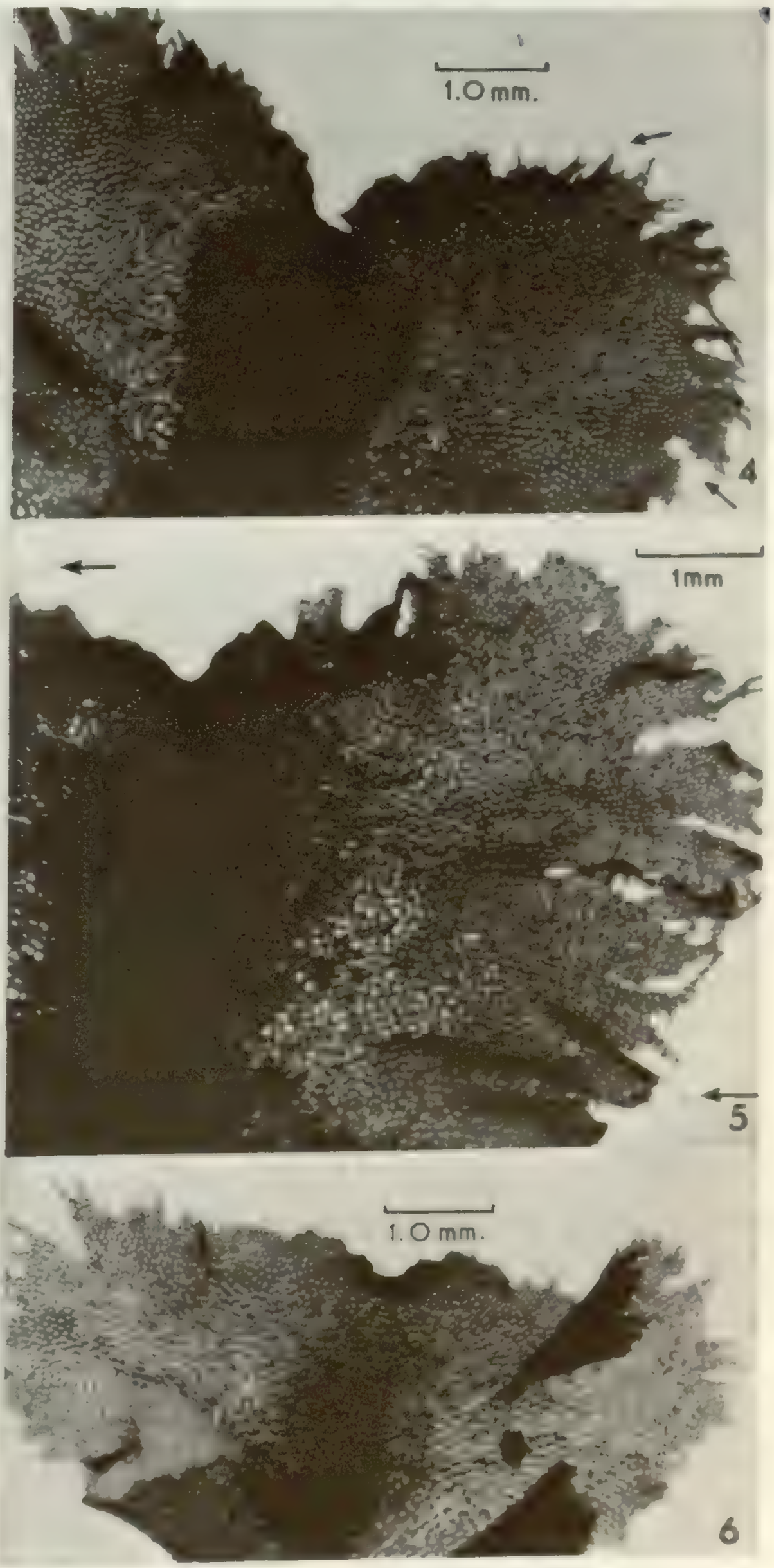

Hypodematium crenatum. Fig. 1. Rhizomes of similar length from different rock crevices showing leaves in three rows (above) and two alternate rows (below), ca. × 0.5. Fig. 2. Arrested buds (arrows) seen in close proximity to the basal part of the petioles, ca. × 0.5. Fig. 3. Transverse sections of the swollen part of the stipes from different plants. Note variations in the orientation of leaf-trace strands and mechanical issue (stippled). × 5. Fig. 4. Portion of adult haploid prothallus (arrows indicate acicular hairs). Fig. 5. Same, diploid prothallus. Fig. 6. Portion of adult diploid prothallus showing complete absence of acicular hairs.

POSITION OF THE LATERAL, ARRESTED BUDS.—We described the mode of vascular supply to the lateral buds as follows: "Traces to the buds are associated with the margin of this meristele (ventral)." In their text and Figure 2 Nayar and Bajpai have shown that "the branch traces are profuse and are restricted to the ventral half of the stelar cylinder. They are similar to the root traces . . . and oriented in the same way (not at the margin of ventral meristele, as Mehra and Loyal (1956) reported." A critical reexamination of a large number of rhizomes in my collection shows that the buds originate in close association with the basal regions of the leaves borne on the two lateral sides of the shoot (*Fig. 2*), anatomically two lateral arms of the V–shaped ventral meristele, as we originally stated. The evidence that we have about the sites of bud inception in some ferns is that they normally develop from the detached meristems, their sites being interfoliar (Wardlaw, 1968). Bower (1923) also described the various positions of buds as lateral, basal on the stipe, etc. In *H. crenatum,* however, they occur in between two lateral sides of the dorsiventrally flattened shoot and the root-forming ventral side, an adaptive feature evolved in response to specialization of the habitat.

Nayar and Bajpai have erroneously drawn similarities between the arrested buds of this fern in response to the apical dominance and the stolons of *Nephrolepis,* although the organs are unquestionably distinct in their structural organization, physiology and function.

SORAL ORGANIZATION.—The symmetry of the sorus has been erroneously described as "circular" by Nayar and Bajpai. In fact, it varies from horse-shoe– to J–shaped, or rarely linear, almost similar to that recorded in some species of *Athyrium.* The reniform indusium, as described by Nayar and Bajpai itself indicates zygomorphic symmetry of the sorus rather than circular. Furthermore, it is pertinent to mention that none of the genera with which this fern is considered to be related has a radially symmetrical sorus.

GAMETOPHYTIC TRICHOMES.—Loyal (1960) stated: "Besides the presence of these glands (capitate hairs) on the margin as well as on both the surfaces, some fully-developed gametophytes produce long bristles . . . These are similar to those on the lamina of fronds." Contrariwise, Nayar and Bajpai have stated: "In addition, all the adult prothalli (not some of them only, as Loyal (1960) reported) bear profuse, much elongate, rhizoid-like hairs ('bristles') on the anterior margin and surfaces . . . Acicular hairs similar to those on the lamina of fronds that Loyal (1960) reported were not found on the prothallus." I have confirmed that haploid and diploid prothalli vary from lacking acicular hairs to having quite a few of them (*Figs. 4–5*), even when cultured under uniform conditions of light, nutrition, and space (crowded or not). It should be noted that my cultural conditions are not expected to be the same as those of Nayar and Bajpai. At present no one knows what factors control the presence or absence of the hairs. However, it is conceivable that their initiation may involve some hitherto unthought-of photo-morphogenetic influence which acts after the gametophyte has reached a certain vegetative and/or reproductive phase. As to the variations in

their extent from prothallus to prothallus, it is presumably reflected in their ontogeny, since they develop from the papillate hairs through extension growth. Another variable factor which can hardly be overlooked is the nuclear constitution of the gametophytes. The northwestern Himalayan populations, from which my material came, include diploid, triploid, and tetraploid cytological races. The above-mentioned variations of trichomes were consistently observed both in haploid and in diploid prothallial cultures. The prothalli raised from the spores of the triploid plants showed diverse chromosomal constitution, and, in contrast to the haploid and diploid prothalli, they followed markedly different morphogenetic development (Loyal & Paik, 1971). Most of them failed to develop trichomes comparable to those of the haploid and diploid prothalli.

The difference between the gametophytic acicular hairs (rhizoid-like hairs, according to Nayar and Bajpai) and those of the frond, as they unduly emphasized, may at best be considered one of degree rather than of kind. This is quite understandable in view of their different nuclear constitution. Incidentally, it may be mentioned that Nayar (1956) published a paper earlier which exclusively deals with similarities between gametophytic and sporophytic trichomes. I therefore see no adequate grounds for Nayar and Bajpai to question my observations of a similar kind.

ARCHEGONIAL NECK.—Nayar and Bajpai have recorded: "The archegonial neck is slender and curved away from the apex of the prothallus, the neck is not straight as Loyal (1960) reported." In fact, I described the neck as "almost straight." The whole axis of the archegonium is inclined away from the apical notch (cf. figs. 11, 12 in Loyal, 1960), but in no case was the neck recurved. Nayar and Bajpai seem to have based their conclusion upon a widely-accepted description of the archegonium in advanced leptosporangiate ferns. This assumption, however, cannot be accepted in view of certain recently recorded exceptions, including the present one. In addition, Stone (1961) has described straight-necked archegonia in *Blechnum nudum,* and Atkinson (1967) has reported straight-necked archegonia in *Diplazium expansum*.

Re-evaluation of published data is helpful only provided it is based upon adequate new observations and a deeper understanding of concepts of organization.

LITERATURE CITED

ATKINSON, LENETTE R. 1967. The gametophyte of Diplazium. Phytomorphology **17:** 99–109.

BIERHORST, D. W. 1971. Morphology of Vascular Plants. Macmillan, New York.

BOWER, F. O. 1923. The Ferns (Filicales), Vol. 1. Cambridge Univ. Press, London.

HAYATA, B. 1927. On the systematic importance of the stelar system in the Filicales. Bot. Mag. Tokyo **41:** 697–718. (Not consulted in the original.)

IWATSUKI, K. 1964. On Hypodematium Kunze. Acta Phytotax. Geobot. **21:** 43–54. (Not consulted in the original.)

LOYAL, D. S. 1960. Some observations on the gametophyte of Hypodematium crenatum (Forsk.) Kuhn with a note on the phyletic affinities of the genus. J. Indian Bot. Soc. **39:** 133–139.

————, and PARMJIT PAIK. 1971. Morphogenetic variations in the gametophyte of a 3× fern—Hypodematium crenatum (Forsk.) Kuhn. Curr. Sci. **40:** 384–385.

MEHRA, P. N. and D. S. LOYAL. 1956. Some observations on the cytology and anatomy of Hypodematium crenatum. Curr. Sci. **25:** 363–364.

NAYAR, B. K. 1956. Correlation between gametophytic and sporophytic trichomes in ferns. Sci. & Culture **21:** 455–457.

————, and NISHA BAJPAI. 1970. A reinvestigation of the morphology of Hypodematium crenatum. Amer. Fern J. **60:** 107–118.

STONE, ILMA G. 1961. The gametophytes of the Victorian Blechnaceae. Blechnum nudum (Labill.) Luerss. Austr. J. Bot. **9:** 20–36.

WARDLAW, C. W. 1968. Morphogenesis in Plants. A Contemporary Study. Meuthuen, London.

REVIEW

"INTERMOUNTAIN FLORA. VASCULAR PLANTS OF THE INTERMOUNTAIN WEST, U. S. A., VOL. 1" by Arthur Cronquist, Arthur H. Holmgren, Noel H. Holmgren, and James L. Reveal. 270 pp. 1972. Published by the Hafner Publishing Co., 866 Third Ave., New York, NY 10022. $17.50.—The Intermountain Region is the semi-desert region of the western United States between the Rocky Mountains on the east and the Sierra Nevada on the west. It is bounded on the north by the high mountains of Idaho and Oregon and on the south by the hot, desert, creosote bush area of Arizona, and so includes all of the state of Utah, most of Nevada, and small parts of Oregon, Idaho, and Arizona. It is thus a natural phytogeographic area rather than an area defined by political boundaries, such as are most floras. This area has been covered by Tidestrom's "Flora of Utah and Nevada," which is now somewhat out of date; since that work had no descriptions or illustrations it was never very usable. The present work, which does have descriptions and fine line drawings of all the species, is the result of many years of study and will provide a definitive account when it is completed. This first volume is mostly devoted to chapters on the physiography of the region, the evolution of the flora, the history of botanical exploration in the region, and the plant geography. The systematic account treats the ferns and fern allies (by Cronquist) and the gymnosperms (by A. and N. Holmgren). Since this is an arid region, ferns are not abundant and are mostly confined to the higher mountains, of which there are several ranges, notably the Uinta and Wasatch Ranges. None of the species is endemic to the area; the rather numerous cheilanthoid ferns are mostly widespread in the western United States, and the others are often widespread subboreal species, sometimes circumboreal. The treatment is carefully prepared and eminently usable. One commendable feature, unusual in floras, is the indication of the types, not only of the accepted species but of the synonyms also. The only error that I have noted is the placing of *Pellaea longimucronata* Hook. as a synonym of *P. truncata* Goodding. This ought to be *P. longimucronata* sensu auctt. non Hook., for Hooker's species is a superfluous and illegitimate substitute name for *P. mucronata*, and by the Code of Botanical Nomenclature (Art. 7) a superfluous name is typified by the type of the name that ought to have been adopted. Therefore the type of *P. longimucronata* Hook. is not *Wright 2131* (New Mexico) but *A. B. Eaton* (California). Students of the ferns of the western United States will surely need to have this volume in their libraries.—*C.V.M.*

A "Filmy Fern" in the Genus Cystopteris[1]

JOHN T. MICKEL*

The northwestern part of the Mexican state of Oaxaca along the border with Puebla is relatively poorly collected botanically. Much of the area between Huajuapan de León, Oax., and Tehuacán, Pue. is extremely dry semidesert. A dry valley extends from Tehuacán to Teotitlán del Camino in Oaxaca. From the latter city there is a road to the northeast that goes over the mountains to the village of Huautla de Jiménez. This road has been best known in recent years for its hallucinogenic fungi, hippies, and police—in that order. The road rises steeply out of Teotitlán and snakes its way up to the top of a ridge, crossing it at Puerto Soledad. The upper parts of the slope are forested with pine and oak. The forest at the top is the wettest and consists largely of oaks and some *Podocarpus*. The wet winds from the Gulf of Mexico keep this region moist the year around. I have collected over 100 species of ferns within two miles of the pass, where the wet forest is nearly continuous. The road continues near the top of the ridge, dives to the bottom of another valley and climbs part of another ridge before reaching Huautla de Jiménez. Most of the road is heavily cultivated or at least cut over. After passing Puerto Soledad, which is 19 miles by road from Teotitlán, the forest is soon interrupted by agriculture, but there are small patches of forest and several waterfalls by the road.

In 1970 Mr. Steven Leonard and I collected a remarkably filmy fern on the ground in the spray beside a small waterfall. At first it looked to us somewhat like *Trichomanes radicans*, for its leaf tissue was only one or two cells thick. But on closer examination I found that the plant had tiny dorsal sori with hood-like indusia typical of *Cystopteris*.

A similar specimen was found at the United States National Herbarium from Veracruz, also from a waterfall. This suggests that the thin frond texture may be due to constant waterfall spray, but apparently this is not the case. A plant was grown for nearly a year in the greenhouse of the New York Botanical Garden, during which time the new leaves continued to be as filmy as those of the original plant. Consequently, I am describing the plant as a new species:

Cystopteris membranifolia Mickel, sp. nov. Fig. 1.

Rhizoma late repens, apice 1–5 mm ultra stipites protrudenti, sparse squamatum, paleis brunneis, ovatis, nitentis. Stipites remoti, viridi, longitudine ½-⅔ laminas aequantes. Lamina lanceolata vel ovato-lanceolata, plerumque pinnato-pinnatifida, usque ad 18 cm longa, 6 cm lata, membranacea, fere glabra, cellulis 1- vel 2-stratosis; pinnae deltoideo-lanceolatae, sessiles; pinnulae late oblongae vel ellipticae, interdum incisae, apicibus obtusis, marginibus dentatis, venis in dentis terminantibus. Sori rotundati, indusiis parvis, evanidis. Sporae bilaterales, tuberculato-echinatae, 26–32 μ longae.

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* The New York Botanical Garden, Bronx, New York 10458.

[1] This research was supported by a grant from the National Science Foundation (GB-13722). I wish to thank Mr. Charles Clare for preparing the illustrations.

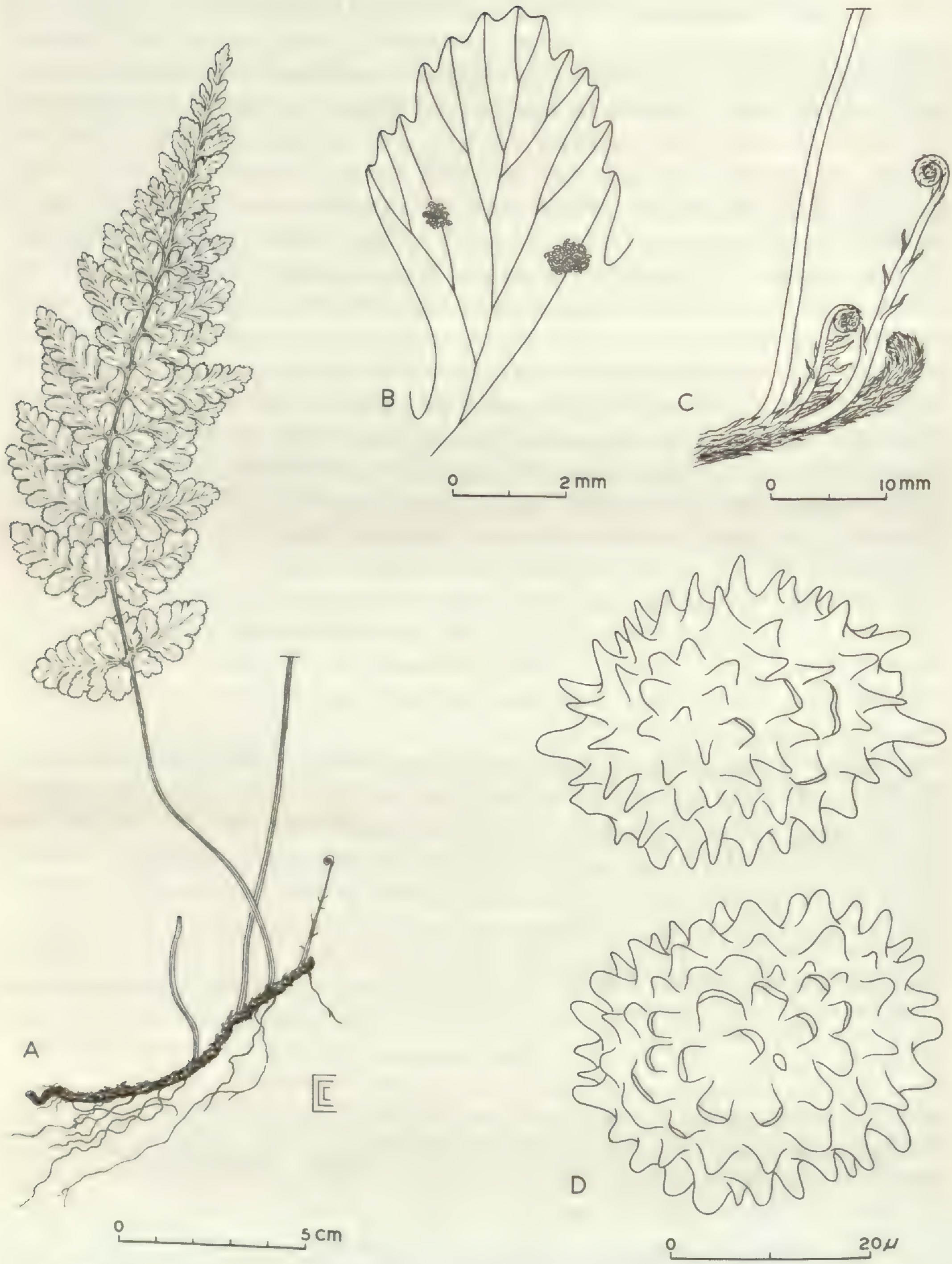

Fig. 1. *Cystopteris membranifolia*. A. Habit. B. Pinnule. C. Rhizone apex. D. Spores.

TYPE: About 33 km NE of Teotitlán del Camino on road to Huautla, by waterfall in cut-over woods, Distrito Teotitlán, Oaxaca, Mexico, ca. 7000 ft alt, 15 Sept 1970, *Mickel 4544* (NY; isotype US).

Other collection seen: Teocelo Falls, Veracruz, Mexico, *S. N. Rhoads s.n.*, March 1899 (US).

This species resembles most closely *Cystopteris protrusa* in its wide-creeping rhizome, which protrudes beyond the leaves, and in its veins, which end in the teeth. But it differs from *C. protrusa* in having a narrower blade, broader pinnules, thinner lamina, and blunter spines on the spores. Furthermore, the rhizome of *C. protrusa* is clothed with fine hairs that resemble root hairs in addition to the sparse, pale scales, whereas *C. membranifolia* has only darker and shinier scales. Although most of the spores seem to be normal, some are much smaller and more irregular in shape and some are somewhat larger and rounder. Whether these reflect irregularities in reproduction or whether this is normal for the species cannot be determined. There are few sporangia per sorus and few sori on the plants, and so the sample is small. The size of the normal spores is precisely that reported by Blasdell[2] for diploid plants of the genus.

I plan to return to the locality with hopes of collecting living plants for cultivation in our new research greenhouse.

[2] Blasdell, R. F. 1963. A monographic study of the fern genus Cystopteris. Mem. Torrey Bot. Club **21**(4): 1–102.

SHORTER NOTES

THE FIRST PERUVIAN RECORD OF ELAPHOGLOSSUM CARDENASII WAGNER.—The most peculiar species of the genus *Elaphoglossum* is the one called *E. cardenasii* by Wagner (Bull. Torrey Bot. Club **81:** 61–67, *figs. 1–7.* 1954). It has pedately lobed fronds, which is most peculiar in a genus of several hundred species characterized by having simple, unlobed blades.

The type and isotype specimens of this rare fern are Bolivian. Since its description, only one other specimen was known, a collection from the same general area reported by Stolze (Amer. Fern J. **58:** 31–32. 1968). During a recent visit to the Herbarium Vargasianum, in Cuzco, Peru, which now is deposited at the Universidad del Cuzco, two specimens collected by C. Buës in a nearby locality (Alturas de Sicre, 10,000 ft., June 1924) were found to be *E. cardenasii* Wagner. These are the first record of the species outside Bolivia. One of the specimens bears an annotation by Wm. Maxon: "a monstrous form." No fertile blades are present, but a regular progression of juvenile fronds are present which might provide data for solving the development of the leaf structure of this interesting fern.—*Luis Diego Gómez P., Herbario Nacional de Costa Rica, Apartado 749, San José, Costa Rica.*

HUMATA BRACKENRIDGEI BROWNLIE, A CORRECTION.—The new name *Humata brackenridgei* Brownlie (Fl. Nouv. Caléd. no. 3 Pterid. 150. 1969) was based on *Humata serrata* Brack. (1854), non Desv. (1827). By a typographical error, a somewhat misleading synonym was cited as "*Humata botrychioides* auct. Brack. loc. cit. 231, t. 32, f. 1; C. Chr.: 59 (1929); C. Chr. in Däniker: 19 (1932), non Desv."; this seems to imply that Brackenridge's second species *H. botrychioides* is also a synonym and also antedated by a species of Desvaux, although actually the true *H. botrychioides* Brack. is a good species occurring widely throughout the mountain forests in Fiji and possibly also in Samoa. The second citation should read: "*Humata botrychioides* auct. C. Chr.: 59 (1929); C. Chr. Däniker: 19 (1932), non Brack."—*G. Brownlie, University of Canterbury, Christchurch, New Zealand.*

A NEW MASSACHUSETTS LOCALITY FOR THE HARTFORD FERN.—Recently I found *Lygodium palmatum* covering an area of approximately three square meters under some White Pines on the bank of a brook tributary to the Scantic River in the Laughing Brook Audubon Sanctuary in Hampden County. Because of the Sanctuary, this heretofore undiscovered colony is likely to persist, which may not be true in other localities in southern New England.—*Kate Miller, Laughing Brook Sanctuary, 789 Main St., Hampden, MA 01036.*

SELAGINELLA MUTICA FOUND IN WYOMING.—While collecting on an exposed granite ridge 23 miles east and 3 miles south of Saratoga, Carbon County, Wyoming, on July 6, 1972, I found a small colony of *Selaginella mutica* D. C. Eaton ex Underw. The ridge followed a spruce wooded stream ravine in the low mountains on the west slope of the Snowy Range. Further searching of the ridge revealed three more small colonies of the plant. The largest colony formed a mat approximately 15 cm long and 5 cm wide. All four colonies were near the crest of the ridge within 25 meters of each other.

The previously recorded range of this species was northern Colorado to eastern Utah, south to Arizona, New Mexico, and trans-Pecos Texas (Cronquist, "Intermountain Flora," 1972). The Wyoming location extended the known range 60 miles to the northwest of the northern Colorado localities. Voucher specimens (*Ralph Brooks 3770*) have been deposited at the University of Kansas and the University of Wyoming.—*Ralph Brooks, Botany Research Laboratory, University of Kansas, 2045 Ave. A, Campus West, Lawrence, Kansas 66044.*

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AMERICAN FERN JOURNAL

Volume 62

Number 4

October–December, 1972

QUARTERLY JOURNAL OF THE AMERICAN FERN SOCIETY

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The "American Fern Journal" is an illustrated quarterly devoted to the general study of ferns. It is owned by the American Fern Society, and published at 3200 Falls Cliff Rd., Baltimore, Md. 21211. Second-class postage paid at Baltimore.

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The Distribution of Thelypteris torresiana in the Southeastern United States[1]

STEVEN W. LEONARD*

Near the turn of this century *Thelypteris torresiana* (Gaud.) Alston, a fern new to the United States, was collected in Seminole County, Florida. Small (1938) mentions that it was first collected in Florida by T. L. Mead about 1906; however, a specimen of this taxon collected by A. A. Eaton, dated May 1904, is among the collections at the United States National Herbarium. Both the Mead and Eaton collections came from the vicinity of Oviedo in Seminole County, and on the label of the Eaton specimen a note was added that the plants were escapes from cultivation.

Although the early collections were identified as *Dryopteris setigera* (Blume) Kuntze, the nomenclatural status of this fern has been clarified by Morton (1962), Ching (1963), Reed (1968), Holttum (1969), and others. True *Dryopteris setigera* is a rare Asian species, probably neither cultivated nor naturalized in the New World. The American collections, erroneously identified as *Dryopteris setigera,* are *Thelypteris torresiana,* a combination made by Alston in 1960 based on Guadichaud-Beaupré's *Polystichum torresianum* from Guam. In a recent study of Old World species of *Thelypteris sensu lato,* Holttum (1969) maintains the combination *Macrothelypteris torresiana* (Gaud.) Ching in his revision of the Thelypteridaceae. Until knowledge of this family is further refined, I have followed a more conservative generic treatment.

After 1904–1906, when the first collections of *Thelypteris torresiana* were made in Florida, there were no additional reports of this fern from the southeastern United States until it was located in Polk County, Florida in 1922. A few years later it turned up in Volusia County (1924) and in Manatee County (1926), both in central penisular Florida. Another ten years elapsed before it was recorded for Highlands and Orange Counties, Florida. In 1938, Small wrote that it was "appearing spontaneously in many remote localities and in great abundance."

The first record of the occurrence of *Thelypteris torresiana* in a state other than Florida was in 1948, when L. C. Crawford located a population in Conecuh County, Alabama. A few years later it was reported from the Coastal Plain of Texas (Newton County) by Correll (1951). It seems likely that by this time *T. torresiana* would have been present also in southern Georgia, southern Mississippi, and Louisiana, although stations in these states were not discovered until 1959, 1961, and 1968, respectively.

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* Department of Botany, University of North Carolina, Chapel Hill, NC 27514.

[1] Acknowledgements. Herbarium specimens for this study have been examined from DUKE, FSU, GA, MICH, NCS, NCU, NY, TENN, US, University of South Alabama, and Northeast Louisiana University. I thank the curators at these institutions for access to the collections under their care. I wish to express appreciation to A. Murray Evans for supplying distribution information for the following counties: Citrus and Hillsborough (Florida); Marshall, Smith, Covington, Amite, Pike, and Marion (Mississippi). Also thanks are extended to Norton Miller for his helpful comments on this manuscript.

Volume 62, number 3, of the Journal, pp. 65–96, was issued October 4, 1972.

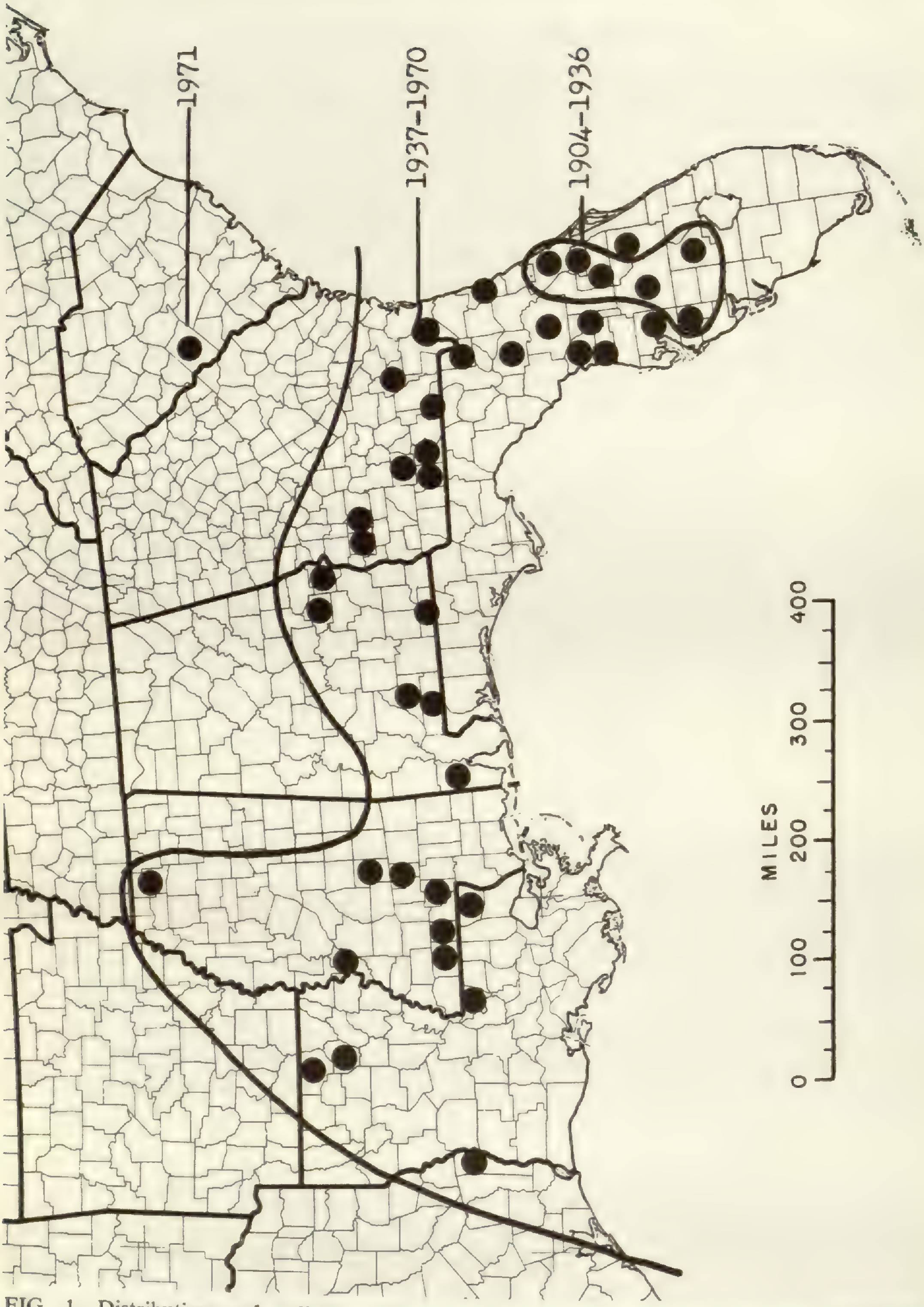

FIG. 1. Distribution and collection dates for *Thelypteris torresiana* in the southeastern United States.

Another state may now be added to the range of *Thelypteris torresiana*. On a field trip to Aiken County, South Carolina, August 23, 1971, the author in the company of J. R. Massey and A. E. Radford discovered a population of *T. torresiana* on a shaded bank of an oxbow in a floodplain forest of the Savannah River, approximately five miles from County Route #5, southeast of Beech Island. Extensive investigation of this area on a later field trip was hampered by heavy rain. However, a few fertile fronds were collected as well as two rhizomes which have grown vigorously in a greenhouse on the campus of the University of North Carolina. Herbarium voucher specimens (*Leonard 4989*, with Massey and Radford; *Leonard 5085*) will be distributed to major herbaria.

The presently known distribution of *Thelypteris torresiana* in the southeastern United States is shown in *Fig. 1*. Examination of herbarium specimens from most counties in this region reveals that the species has been collected most often along streams, frequently near or under bridges, and occasionally in forests over rocky soil derived from limestone. Evidently it prefers cool, moist habitats, and at least at the South Carolina station it thrives in light of low intensity. Based on my experience with the species and its distribution as indicated in *Fig. 1*, it should also occur in Arkansas. Other stations within its presently known range undoubtedly will be found. Moist ravines and banks of Coastal Plain creeks and rivers are promising localities for future exploration.

LITERATURE CITED

CHING, R. C. 1963. A re-classification of the family Thelypteridaceae from the mainland of Asia. Acta Phytotax. Sinica **8:** 289–335.

CORRELL, D. S. 1951. Dryopteris setigera in Texas. Amer. Fern. J. **41:** 124.

HOLTTUM, R. E. 1969. Studies in the family Thelypteridaceae. The genera Phegopteris, Pseudodophegopteris, and Macrothelypteris. Blumea **17:** 5–32.

MORTON, C. V. 1962. Another name change for the Florida fern known as Dryopteris setigera. Amer. Fern J. **52:** 27–29.

REED, C. F. 1968. Index Thelypteridis. Phytologia **17:** 249–328.

SMALL, J. K. 1938. Ferns of the Southeastern States. Science Press, Lancaster, Pa.

James Leland Edwards

Lee Edwards, as he was more commonly known to the members of the Fern Society, passed away on July 31, 1972 at the age of 77. He was born in East Berlin, Connecticut on June 13, 1895, and graduated from Cornell University in 1917. After serving in the First World War with the Army Air Force, he practiced civil engineering with the firm of Edwards and H. J. Roth of New York. Lee was a member of the American Fern Society from 1932, and was an honorary member of many New Jersey nature and bird clubs. He had a keen knowledge of all of the ferns of New Jersey and was also a specialist in wild orchids. In 1947 Rutgers published the "Ferns of New Jersey" of which he was co-author with the late M. A. Chrysler.

Neurocallis praestantissima in Costa Rica

LUIS DIEGO GÓMEZ P.*

In 1904 Charles Wercklé, the French–Costa Rican gardener and collector, sent a depauperate specimen of *Neurocallis praestantissima* (Bory) Fée to Hermann Christ, who was then working on the Filicales for Durand and Pittier's "Primitiae Florae Costaricensis." Christ described the fern as a new species, *Pteris macrodictya* (Bull. Herb. Boiss. II, **7:** 267. 1907), and related it to *P. haenkeana* Presl and to *P. podophylla* Swartz. He remarked that although the specimen was sterile and fragmentary, the uniqueness of the new species laid in the entire margins, coarsely reticulate venation, and herbaceous texture of the pinnae, and in the general resemblance of the plant to *Hemidictyum marginatum* Presl, a set of characters not found in any of the known species of *Pteris*.

Two months later, in his "Appendice aux Primitiae Costaricensis Filic. V." (Bull Herb. Boiss. II, **7:** 585. 1907), Christ corrected his earlier publication and recognized that the Wercklé collection was actually the first continental record of *N. praestantissima,* described from the West Indies in 1845. This emendation was overlooked by Scamman (Rhodora **63:** 205. 1961), who supposed that *P. macrodictya* Christ was *P. grandifolia* L. J. G. Baker made the same mistake as Christ did when he described and illustrated *Pteris dominicensis* Baker in Hooker (Ic. Pl. **3:** 1642. 1886), an error later corrected by Jenman (Ferns Brit. West Ind. & Guian. [Misc. Inf. Bot. Dept. Trinidad **23**] 118. 1900).

After the collection by Wercklé, who as usual did not cite a locality for his plant, *Neurocallis* was never again reported for Costa Rica. But during a recent field trip to Patillo, in the mountains ENE of Tapantí, Prov. Cartago, I located a large population of this fern (*Gómez & Kennedy 3345,* CR). The specimens were collected in a dense rain forest, where several species of *Bolbitis, Cyathea, Diplazium,* and *Thelypteris* were abundant.

The specimens showed a number of characters worth noting. In the material described by Fée and in the other specimens I have seen, the pinnae are either sessile or short-petiolulate (2–3 mm). All the Costa Rican material has petiolules ranging from 7 to 11 mm. In most Antillean collections the pinnae have moderately acuminate to almost obtuse apices. Most of the plants from Tapantí have long-acuminate pinnae, and some are close to being caudate. The rhizome, which has been described as paleate, is very short-creeping to suberect in our plants, and bears a very few, minute, rigid, narrow, reddish brown setae. The mature fertile pinnae are not linear, but rather wide, with medial to submarginal rows of sori parallel to the costa, which are protected by a wide, chartaceous, reflexed margin. In typical *Neurocallis,* the sporangia cover the entire surface, which accounts for the placing of this genus near *Acrostichum.*

* Herbario Nacional de Costa Rica, Apartado 749, San José, Costa Rica.

A Revision of the Fern Genus Niphidium[1]

DAVID B. LELLINGER* #00215?5

In the "Index Filicum" Carl Christensen hazarded a guess that the several supposed species of *Polypodium* subg. *Anaxetum* were but one species, *P. crassifolium* L. The members of this subgenus all have simple, elongate fronds with but a single row of sori between the principal side veins. Prior to Christensen, Fée, Raddi, Rosenstock, and Willdenow had named species that are not distinguishable from *P. crassifolium*. On the other hand, I have concluded that Cavanilles, Kunze, Mettenius, and Rosenstock did name valid species, and I have distinguished five more new species.

What led me into this revision was a routine identification for the National Institutes of Health anti-cancer drug screening program. I was asked to identify a specimen from Ecuador that appeared at first glance to be *P. crassifolium*. But careful study showed it to be a different species. Examination of all of the South American specimens of subg. *Anaxetum* revealed many that could not be included in *P. crassifolium*. Mr. C. V. Morton called to my attention the Ecuadorian species usually known as *Niphidium americanum*. It is clearly related to the other species of this group. Because it bears the oldest available generic name, *Niphidium* takes precedence over *Pessopteris* when these species are considered a distinct genus.

The genus *Niphidium* is distinct from *Polypodium* and its subgenera or generic segregates *Microgramma, Microsorium, Phlebodium,* and *Pleopeltis* in two characters. The sori are in one series between straight, well-defined lateral veins. The sori appear compital, but in fact an irregular ring of vascular tissue underlies the receptacle (*Fig. 13*). All the species of *Niphidium* have rather similar rhizome scales (*Figs. 1–10*), large, simple fronds with similar venation patterns, and smooth, monolete spores.

Because the relatively slight differences among the species of *Niphidium* make comparison among the descriptions useful, they are all parallel and in English. The new species are provided with a mere Latin diagnosis, rather than a full Latin description.

The taxonomic characters most useful for distinguishing the species of *Niphidium* are found in the rhizome scales. Identification of specimens lacking the rhizome may be impossible in regions where species with similar fronds overlap (e.g., *N. crassifolium* and *N. rufosquamatum* in southeastern Brazil and northeastern Argentina and *N. albopunctatissimum* and *N. crassifolium* from Colombia to Bolivia).

Table I summarizes the evolutionarily important characters. Zero indicates the primitive condition in the genus, 1 the specialized, and 2 the super-specialized.

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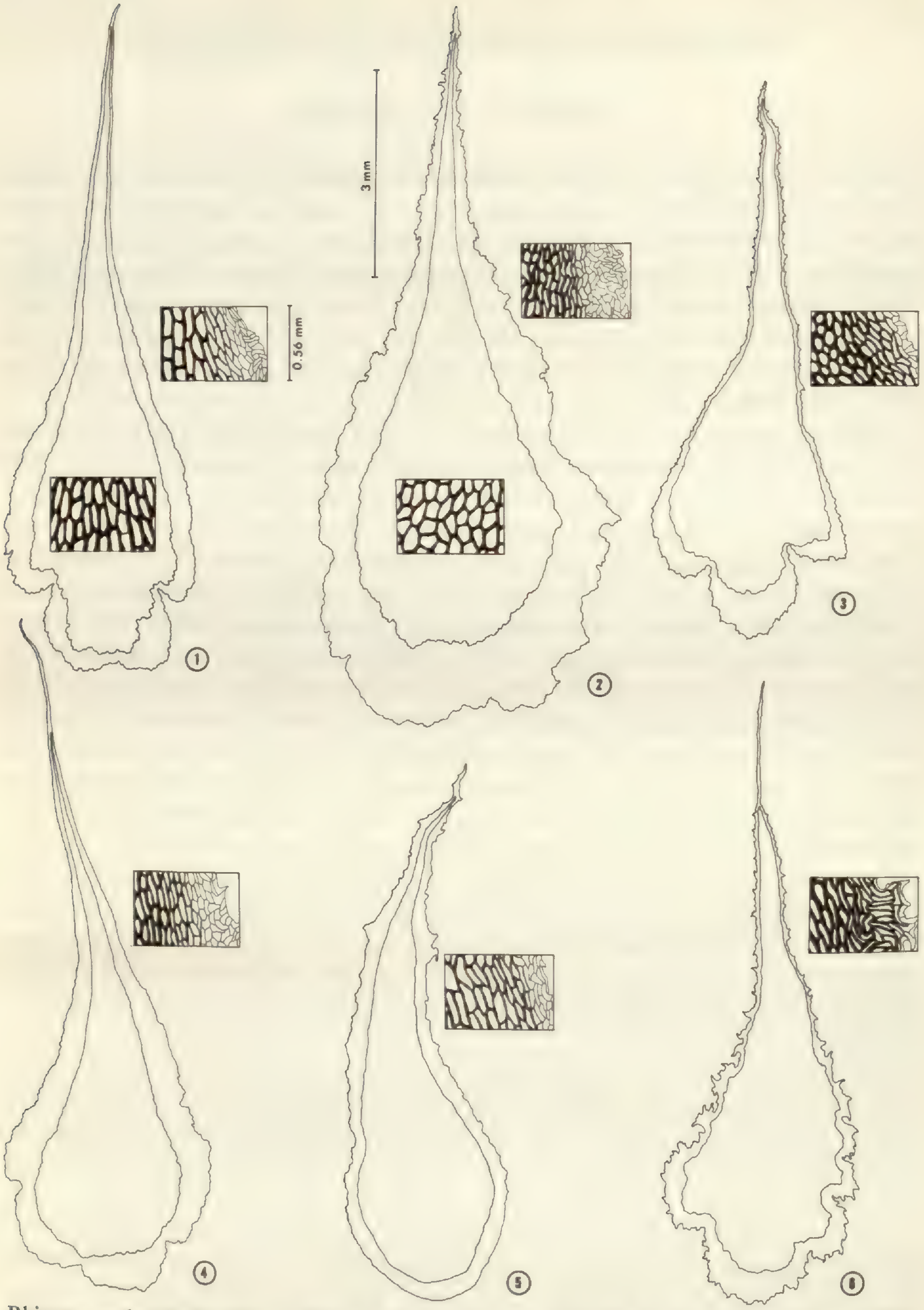
* U. S. National Herbarium, Smithsonian Institution, Washington, DC 20560.

[1] I wish to thank the curators of the herbaria from which I borrowed specimens for their cooperation. Partial expenses of publication of this paper have been borne by the Smithsonian Institution. I also wish to thank Miss Alice Tangerini, who prepared the drawings of the scales.



Rhizome scales of *Niphidium*. FIG. 1. *N. crassifolium*. FIG. 2. *N. albopunctatissimum*. FIG. 3. *N. nidulare*. FIG. 4. *N. carinatum*. FIG. 5. *N. rufosquamatum*. FIG. 6. *N. mortonianum*.

The sequences are believed to be correct because the evolutionary ground plan pattern (*Fig. 14*) is parsimonious. The letters indicate the characters and the numbers the amount of advancement of the characteristics. The smaller, unnumbered dots lack names and are hypothetical species.

Of the ten species of *Niphidium,* seven are Andean. One is from Costa Rica, and another is from southeastern Brazil and northeastern Argentina. *Niphidium crassifolium* is the only widespread species; it is found throughout tropical America. It is also an unspecialized species, although probably it is not the ground plan ancestor of the group.

Niphidium crassifolium is predominantly epiphytic, but is epipetric or terrestrial occasionally, particularly at its upper altitudinal limit. *Niphidium anocarpos, N. nidulare,* and *N. rufosquamatum* are also usually epiphytic. *Niphidium carinatum* is equally epiphytic or epipetric. The other five species (all Andean) are epipetric or terrestrial, and only rarely or occasionally epiphytic.

I found one name to exclude: *Polypodium crassifolium* f. *angustissimum* Rosenst. (Mém. Soc. Neuchat. **5:** 45. 1913), which is *P. angustifolium* Swartz.

Niphidium J. Smith, Hist. Fil. 99. 1875.

Anaxetum Schott, Gen. Fil. *t. 1.* 1834, *nec Anaxeton* Gaertn. Fruct. **2:** 406. 1791, *nec Anaxeton* Schrank, Denkschr. Akad. München **8:** 146, 162. 1824 (both Compositae). TYPE (and sole original species): *Polypodium crassifolium* L. [=*Anaxetum crassifolium* (L.) Schott].

Phymatodes sect. *Pleuridium* Presl, Tent. Pterid. 196. 1836. LECTOTYPE: *Polypodium crassifolium* L. [=*Phymatodes crassifolia* (L.) Presl], chosen by J. Smith (Hist. Fil. 94. 1875).

Pleuridium (Presl) Fée, Gen. Fil. 273. 1850–52 [1852], *non* Bridel, Mant. Musc. 10. 1819 (Musci).

Pessopteris Underw. & Maxon, Contr. U. S. Nat. Herb. **10:** 485. 1908. TYPE (and sole species): *Polypodium crassifolium* L. [=*Pessopteris crassifolia* (L.) Underw. & Maxon].

Rhizomes short- to long-creeping, the younger portions densely covered with roots bearing a fine tomentum of root hairs, the older portions often without roots, dictyostelic, scaly, the scales lanceolate-acuminate, in some species narrowly so, concolorous to sharply bicolorous, attached near the base to almost centrally; stipes coarse, tan, scaly only at the base, usually 1–5 cm distant, articulate, the phyllopodia obsolete to 1 cm long; laminae simple, narrowly elliptic-lanceolate to oblong, attenuate to long-attenuate at the base, rounded, acute, or acuminate at the apex, coriaceous, often glaucous, often white-dotted or with dark brown or black hydathodes above, sometimes with a few rhizome-type scales along midrib, the main veins straight, ascending, prominulous beneath, the secondary veins immersed, forming inconspicuous, irregular, transverse areolae with numerous minor areolae containing numerous excurrent and recurrent free veinlets; sori solitary in the major areolae, forming single rows of (3)5–12(15) sori between the main veins, appearing compital but the veins forming an irregular ring beneath the sorus, round or slightly oblong transversely between the main veins, superficial, the receptacle dark brown, paraphyses (abortive sporangia) sometimes numerous, sporangia sometimes with multicellular, hyaline, linear or slightly clavate hairs on the capsule, annulus (11)12–15 thickened cells; spores bilateral, hyaline, smooth, often empty in some species.

TYPE (and sole original species): *Polypodium americanum Hook.* [=*Niphidium longifolium* (Cav.) Morton & Lellinger].

10. Rhizome scales weakly bicolorous, pale brown in mass, thin and fragile, the central cells in the apical portion of the scale isodiametric, their lumina large; rhizomes conspicuously pruinose beneath the scales; luminae 3.5–6.5(8) cm broad (Peru & Bolivia) .....*7. N. macbridei*

1. Niphidium crassifolium (L.) Lellinger, comb. nov. Fig. 1.

Polypodium crassifolium L. Sp. Pl **2:** 1083. 1753. LECTOTYPE: Linnaeus' original description cites two phrase names from Petiver's "Pterigraphia Americana," 1712, both of which lack descriptions but which are accompanied by small, obviously identifiable figures with rather inadequate analyses. Petiver's *t. 6, f. 8.* ("Phyllitis maculata, amplissimo folio") is a redrawn, left-to-right transposition of the far superior *t. 123* in Plumier's "Tractatus de Filicibus Americanis," 1705. There is a full description of this plate by Plumier on p. 107, and the source of his specimen is "dans les forests de l'isle Saint Domingue, particuliérement dans celles du quartier de Léogane." Petiver's *t. 6, f. 1.* ("Phyllitis maculata breviori & crassiori folio") is a similarly redrawn transposition of *t. 142* in Plumier's "Tractatus," which is said on p. 122 to be based on a specimen collected ". . . sur le Morne de la Calebasse à la Martinique." The specimen of *P. crassifolium* in the Linnaean Herbarium must have been added after the publication of *P. crassifolium* and surely did not form part of the protologue, for Linnaeus himself misidentified this specimen as his own *P. phyllitidis.* I choose as the lectotype *t. 6, f. 1.* of Petiver's "Pterigraphia Americana," solely because the drawing of the capsule illustrates the hairs that are characteristic of about 90% of the West Indian specimens of this species that I have examined.

Polypodium porrectum Willd. Sp. Pl., ed. 4, **5:** 161. 1810. TYPE: "Habitat in sylvis umbrosis ad Caracas," Venezuela, *Bredemeyer* (B-Hb. Willd. not seen photo by Tryon US, fragment US; isotype W).

Polypodium coriaceum Raddi, Opusc. Sci. Bol. **3:** 286. 1819; Pl. Bras. **1:** 16, *t. 25.* 1825, *nec* Swartz, 1788, Roxb., 1844, Mett., 1857, *non* Kuhn, 1868. TYPE: "Invenitur in veteribus truncis arborum, nec non in rupibus umbrosis montium estrellensium, praesertim Corco-secco," Brazil, *Raddi* (PI, labelled "Polyp: coriaceum *nob*: e Brasilia").

Anaxetum crassifolium (L.) Schott, Gen. Pl. 1. 1834, *nom. illeg.*

Phymatodes crassifolia (L.) Presl, Tent. Pterid. 197. 1836.

Phyamtodes porrecta (Willd.) Presl, Tent. Pterid. 197. 1836.

Drynaria crassifolia (L.) J. Smith, J. Bot. **4:** 61. 1841.

Dipteris crassifolia (L.) J. Smith, London J. Bot. **1:** 196. 1842.

Pleuridium crassifolium (L.) Fée, Gen. Fil. 274. 1852, *nom. illeg.*

Pleuridium augustum Fée, Mém. Foug. **8:** 98. 1857, *nom illeg.* TYPE: "Nouvelle-Grenade dans les forêts de la province d'Ocaña," Depto. Norte de Santander, Colombia, ca 2400 m, *Schlim 610* (BR; isotypes HB, L, W).

Pleopeltis crassifolia (L.) Moore, Ind. Fil. LXXVIII. 1857.

Polypodium crassifolium f. *genuinum* Hieron. Bot. Jahrb. Engler **34:** 538. 1904, as "*genuina.*"

Pessopteris crassifolia (L.) Underw. & Maxon, Contr. U. S. Nat. Herb. **10:** 485. 1908.

Rhizomes creeping, (5)8–12 mm in diam, rarely pruinose, phyllopodia 5 mm long, 3–5 mm wide; rhizome scales lanceolate-acuminate, ca 8–12 mm long, 2.5–4 mm wide, plane throughout, usually strongly bicolorous, the central band blackish, the cells usually strongly clathrate, those above the base (2)3–5 × longer than wide, the margins pale tan, entire or slightly repand, sometimes erose in age, up to 0.5 mm wide at the base, 0.15 mm wide toward the apex, the cells elongate toward the apex. Stipes 5–15(50) cm long, 3–5(9) mm in diam, adaxially flattened or sulcate. Laminae usually narrowly oblanceolate, sometimes narrowly lanceolate, the juveniles linear-lanceolate, attenuate or acuminate at the base, acute to rounded (sometimes with a small, acuminate tip) at the apex, (30)45–80(105) cm long, 6–11(18) cm wide, dark green above

in life, brown and often glaucous above when dry, with brown hydathodes, paler beneath; midrib scales up to 2 mm long, 0.75 mm wide, like those of the rhizome, caducous, seldom seen; principal veins 5–8(12) mm distant, closer in juvenile and partially developed fronds; sori round or slightly elongate transversely in the largest specimens, 1.5–3.5(5) mm in diam; sporangia with up to 10 deciduous, linear to slightly clavate, (1)2-celled hairs on the capsule; paraphyses (abortive sporangia) usually common among the sporangia; empty spores common.

RANGE AND HABITAT: Tropical America. Epiphytic (occasionally epipetric, terrestrial, or on old walls) at all forested altitudes, but mostly below 1500 m.

Specimens lacking rhizome scales or with old and badly eroded scales cannot be distinguished readily from *N. rufosquamatum* and *N. albopunctatissimum*. Such specimens have been annotated *N. crassifolium sensu lato*. I have found no character beyond the rhizome scales that distinguishes *N. crassifolium* from *N. rufosquamatum*. Habitat is a fairly reliable differentiating character between *N. albopunctatissimum* and *N. crassifolium*. The former species is terrestrial or epipetric about 95% of the time and epiphytic only 5%. But this difference is less reliable for *N. crassifolium*, which is epiphytic about 88% of the time and not 12%. In contrast to *N. crassifolium*, *N. albopunctatissimum* usually is white-dotted above. This is the basis for Linden's invalidly published epithet that was taken up by J. Smith (Ferns Brit. & For. 95. 1866). The sporangial hairs I have examined of *N. crassifolium* are 1(2)-celled, whereas those of *N. albopunctatissimum* are (2)3-celled; this difference is not entirely diagnostic or consistent.

The rhizome scales of *N. crassifolium* are very uniform throughout the Antilles and Central America, but in South America some are less strongly lanceolate because their pale margins are somewhat broader. This makes separating some specimens of *N. crassifolium* from *N. albopunctatissimum* a little difficult, particularly when the rhizome scales are not in good condition.

The root mass of *N. crassifolium* has been recorded as housing a colony of huge, fierce ants (Nicaragua, *Bunting & Licht 1248*), and the plant is said to be the host of the fungus *Caliciopsis maxima* (B. & C.) Höhnd. (Costa Rica, *Alfaro 71*).

REPRESENTATIVE SPECIMENS EXAMINED:

CUBA: Pinar del Río: N of San Diego de los Baños, *Palmer & Riley 639* (US). **Las Villas:** Trinidad Mountains, Río Negro, Arroyo Trinitario, 550 m, *Britton & Britton 5171* (NY). **Oriente:** Near Monte Verde, *Wright 1022* (L, LE, NY, US); Near Jaguëy, 800 m, *Eggers 4952* (F, NY, US). **JAMAICA:** Morces Gap, 500 ft, *Clute 70* (NY, US); Hermitage Dam and vicinity, 500 m, *Maxon 8822* (GH, US); Cooks Bottom, N of Ipswich, 400–450 m, *Maxon & Killip 1446* (F, GH, NY, US). **HISPANIOLA: Haiti:** Massif de la Selle, Croix-des-Bouquets, ca 1500 m, *Ekman III H7782* (F, NY, US); Vicinity of Mission, Fonds Varettes, ca 1000 m, *Leonard 3937* (GH, US). **Dominican Republic:** Montiada Nueva, SE of Polo, 3500 ft, *Howard & Howard 8537* (GH, NY); San José de las Matas, Jiconié, 625 m, *Valeur 308* (F, L, NY, US). **PORTO RICO:** 13 mi N of Cayey on military road, *Underwood & Griggs 284* (NY, US); Alto de la Bandera, near Adjuntas, *Britton & Shafer 2078* (F, NY, US). **LESSER ANTILLES: St. Croix:** *Hornemann* in 1837 (LE). **Saba:** 23 Apr 1885, *Suringar* (L, US). **Montserrat:** Woodlands Mountain, *Shafer 578* (F, NY, US). **Guadeloupe:** Bois des Vieux-Habitants, 200–700 m, *Düss 4096* (F, GH, NY, US). **Dominica:**

Lisdara, 457 m, *Hodge 33* (GH, NY, US); W side of steep hill behind Sylvania Estate, 2200 ft, *Lellinger 421* (BM, GH, IJ, ISC, LP, TRIN, US). **Martinique:** *Sieber 351* (LE, NY); *Düss 1671* (NY, US). **St. Lucia:** Savanne Edmund district, SE of Piton Troumassée, 1800–2000 ft, *Proctor 17954* (GH). **St. Vincent:** Along Chateaubelair River, 300–400 m, *Morton 5204* (US). **Barbados:** *Herb. Jenman* (NY). **Trinidad:** *Fendler 103* (GH, LE, NY, US); Tahaquite, 12 Oct 1918, *Broadway* (F, NY, US).

MEXICO: Querétaro: *Arsène 10656* (US). **Veracruz:** Near Cerro Tapalcapan and Cerro Mastagata, NW of Catemaco, region of San Andrés Tuxtla, *Dressler & Jones 156* (F, GH, MICH, NY, US); Region of Orizaba, *Bourgeau 3606* (LE, NY, US). **Puebla:** Near Necaxa, *Sanchez M. 607* (US). **Oaxaca:** Valley of the Yelagago River, ca 20 mi NE of Villa Alta, ca 3800 ft, *Mickel 1013* (MICH, US). **Chiapas:** Volcán Tacana, 1400 m, *Matuda 2770* (F, MICH, NY, US). **GUATEMALA: El Petén:** Dos Arroyos to Yaloch, *Bartlett 12845* (MICH, US). **El Quiché:** Quiché, *Aguilar 787* (F). **Huehuetenango:** Maxbal, 1500 m, *Steyermark 48837* (F). **Alta Verapaz:** Cobán, 4300 ft, *von Türckheim 553* (US). **Izabal:** Vicinity of Quiriguá, 75–225 m, *Standley 24465* (GH, NY, US). **San Marcos:** Rodeo, 750 m, *Standley 68738* (F). **Quezaltenango:** *Muenscher 12124* (F). **Guatemala:** Guatemala City, 1500 m, *Steyermark 39874* (F). **Escuintla:** 540–720 m, *Standley 63364* (F). **BRITISH HONDURAS: El Cayo:** Mountain Pine Ridge, *Bartlett 13057* (MICH, US). **Toledo:** Near Jacinto Creek, 9 mi, Punta Gorda–San Antonio Road, *Gentle 4964* (US). **Stann Creek:** Middlesex, *Gentle 2841* (GH, MICH, NY, US); Big Creek, *Schipp 88* (F, GH, MICH, NY, US). **HONDURAS: Cortés:** Headwaters of the Río Lindo, 630 m, *Williams & Molina R. 11402* (F, US). **Comayagua:** Near El Achote, hills above the plains of Siguatepeque, 1350 m, *Yuncker et al. 6437* (MICH, US). **Francisco Morazán:** Mt. Uyuca, 5800 ft, *Glassman 2193* (F, NY). **Atlántida:** Foothills back of Ceiba, *Yuncker et al. 8005* (F, GH, NY). **NICARAGUA: Zelaya:** Vicinity of Bluefields, 0–60 m, *Bunting & Licht 1248* (F, GH, NY). **Matagalpa:** Santa María de Ostuma, 1300–1500 m, *L. O. Williams et al. 23622* (F, US). **Jinotega:** E of Jinotega, 1400–1500 m, *Standley 10008* (F). **Chontales:** La Libertad, 500–700 m, *Standley 9021* (F). **COSTA RICA: Guanacaste:** El Silencio de Tilarán, *Brenes 15652* (F, NY). **Puntarenas:** Río del Convento, Bassin du Diquís, 200 m, *Pittier 12099* (CR, US). **Alajuela:** Near San Ramón, *Tonduz 17575* (F, GH, US). **Limón:** Flot de la Uvita, Puerto Limón, *Pittier 12702* (CR, US). **Heredia:** Near Cariblanco, near the Río Sarapiquí, 800 m, *L. O. Williams 20328* (EAP, US). **San José:** Vicinity of El General, 880 m, *Skutch 2954* (GH, NY, US). **Cartago:** El Alto, near the continental divide, 5100 ft, *Stork 1081* (MICH, US). **PANAMA: Bocas del Toro:** Río Cricamola between Finca St. Louis and Konkintoë, ca 10–50 m, *Woodson et al. 1885* (GH, NY, US). **Chiriquí:** Forests around El Boquete, 1000–1300 m, *Pittier 2971* (US). **Coclé:** Hills NE of El Valle de Antón, 2000 ft, *Lewis et al. 1700* (GH, MO, US). **Canal Zone:** Barro Colorado Island, *Shattuck 58, 383* (both F, US). **Colón:** Vicinity of Porto Bello, 5–200 m, *Maxon 5783* (GH, NY, US). **Panamá:** Cerro Campana, *Bartlett & Lasser 16927* (GH, MICH). **Darién:** Vicinity of Cana, 2500 ft, *Stern et al. 553* (GH, US).

VENEZUELA: Distrito Federal: S slope of Cerro Avila, 1800 m, *Vogl 60* (F). **Lara:** Río Calro, *Santiago 47* (F). **Mérida:** Near Colonia Tovar, *Fendler 223* (GH, MO, NY). **Bolívar:** Cerro Guaiquinima, Río Paragua, 1100 m, *Maguire 33129* (F, NY). **COLOMBIA: Magdalena:** Las Partidas, 3500 ft, *H. H. Smith 1039* (F, MICH, NY, US). **Bolívar:** Lands of Loba, Norosi–Tiquisio trail, 150–600 m, *Curran 133* (GH, NY, US). **Cundinamarca:** Below Tausa, ca 22 km NE of Zipaquirá, 2750 m, *Tryon & Tryon 6154* (GH). **Meta:** Río Güejar ca 10 km below junction with Río Zanza, 470 m, *Smith & Idrobo 1519* (GH, UC, US). **Vaupés:** Río Papurí, mountain below Teresita, *Schultes & Cabrera 19479* (GH, US). **Huila:** Canyon of the Río de Las Ceibas, 25–40 km SE of Neiva, 6500 ft, *Little 9307* (US). **Antioquia:** 1 km E of the Turbo–Chigorodó road up the Río Vijagual, ca 100 m, *Feddema 2021* (US). **Chocó:** Lower Río Truando 3–12 km SSW of Riosucio, 2–4 m, *Lellinger & de la Sota 610* (COL, CR, LP, US). **Valle:** Río Calima between La Esperanza and Bellavista, 5–10 m, *Cuatrecasas 16801* (US). **Nariño:** Las Lajas, near Ipiales, *Balls*

B7364 (UC, US). **ECUADOR: Manabí:** Km 82, road from Chone to Pichincha, 450 m, *Dodson & Thien 1776* (MO, US). **Guayas:** Upper Río Guayas, *Rimbach 23* (GH, NY); 1–8 km N of Sevilla de Oro, 8000–9000 ft, *Camp E-4569* (F, GH, MO, NY, UC). **Carchí:** Near Angel, 3200–3300 m, *Mexia 7448* (GH, MICH, UC, US). **Imbabura:** Hacienda La Victoria, 2345 m, *Mexia 7425* (F). **Pichincha:** Vicinity of Quito, 2900 m, *Holdridge 1512* (NY, UC). **Los Rios:** Near Quevedo, ca 50 m, *Mexia 6614* (GH, UC, US). **Bolívar:** Limón, 800–1100 m, *Acosta Solís 6375* (F). **Loxa:** Cajanuma, 2400 ft, *Espinosa 357* (GH). **PERU: San Martín:** Jepelasio near Moyobamba, 890–1200 m, *Woytkowski 35322* (MO, UC). **Loreto:** Gamitanacocha Río Mazán, 100–125 m, *Schunke 286* (F, GH, NY, UC); Above Pongo de Manseriche, streamlet near mouth of the Río Santiago, 210 m, *Mexia 6195a* (F, GH, MO, NY, UC). **Huánuco:** Huánuco, Hacienda Mercedes, 1020 m, *Mexia 8223* (F). **Junín:** Río Paucartambo Valley, near Perene Bridge, 700 m, *Killip & Smith 25265* (NY, US). **Cuzco:** Machu Picchu, ca 2100 m, *Cook & Gilbert 864* (US). **BOLIVIA: La Paz:** North Yungas, Polo-Polo, near Coroico, 1100 m, *Buchtien 3539* (F, GH, NY, UC). **BRAZIL: Rondônia:** Rio Laje on road to Guajará–Mirim to Riberão, *Prance et al. 6740* (F). **Bahía:** Porto Seguro, Km 5 on BR-5, *Duarte & Brade 6735* (F, LP). **Minas Gerais:** Districto Carangola, 3 leagues S of Areponga, trail to Areponga to Fazenda de Grama, 900 m, *Mexia 4227* (F, MO, NY). **Rio de Janeiro:** Friburgo, 30 Nov 1963, *Dunge* (LP). **São Paulo:** Alto de Serra, *Wacket 130* (UC). **SURINAME:** Tibiti Savanna, bank of the Tibiti River, *Kramer 1907* (US). **GUAYANA:** Watershed between the Rupununi and Kuyuwini Rivers, Parabaru Savanna, *A. C. Smith 3045* (F, GH, MO, NY).

2. Niphidium albopunctatissimum Lellinger, sp. nov. Figs. 2 and 15.

Polypodium albopunctatissimum Linden, Cat. 1860, *nom. nud.* This name appears in a list of cultivated plants. There is no description.

Pleuridium albopunctatissimum J. Smith, Ferns Br. & For., ed. 1: 95. 1866, *nom. nud.* Apparently Linden distributed a living plant bearing the name *Polypodium albopunctatissimum* to Kew. I have seen an electrostatic copy of a specimen (BM) made in 1862 from such a cultivated plant bearing the name *Pleuridium albopunctatissimum* in J. Smith's own hand.

Polypodium crassifolium var. *longipes* Rosenst. Rep. Sp. Nov. Fedde **11:** 58. 1912. TYPE: North Yungas, Unudavi, Prov. La Paz, Bolivia, 3300 m, *Buchtien 2757* [cited by Rosenstock as *2750*] (S-PA Morton photo 20636 US; isotype US).

Ab *N. crassifolio* in margine squamarum rhizomatis repando, plus quam 0.3 mm lato, cellulis centralibus 1–2(3) × longiores quam latiores differt.

Rhizomes creeping, 8–10 mm in diam, often pruinose, phyllopodia 2–10 mm long, 3–5 mm wide, rhizome scales broadly lanceolate-acuminate, ca 7–10 mm long, 2–5 mm wide, plane and repand throughout, usually strongly bicolorous, the central band brownish, the cells usually strongly clathrate, those above the base 1–2(3) × longer than wide, the margins pale tan, up to 1.25 mm wide at the base, 0.5 mm wide at the apex, the cells not elongate toward the apex. Stipes 5–30(45) cm long or occasionally obsolete, (3)4–5 mm in diam, adaxially sulcate. Laminae linear-lanceolate, attenuate or acuminate at the base, acuminate or acute at the apex, (15)35–90 cm long, (3)7–11.5 cm wide, pale green above in life, brown above when dry with the hydathodes often encrusted with white deposits, paler beneath; midrib scales up to 3 mm long, 1.5 mm wide, like those of the rhizome, caducous, seldom seen; principal veins 5–7(8) mm distant, 0.5–1 mm closer in juvenile and partially developed fronds; sori round or slightly elongate transversely in the largest specimens, 2–4(5) mm in diam; sporangia with up to ca 10 deciduous, linear, 2(3)-celled hairs on the capsule; paraphyses (abortive sporangia) rare among the sporangia.

TYPE: Apolo, Prov. La Paz, Bolivia, 4800 ft, *R. S. Williams 1062* (NY; isotypes GH, US).

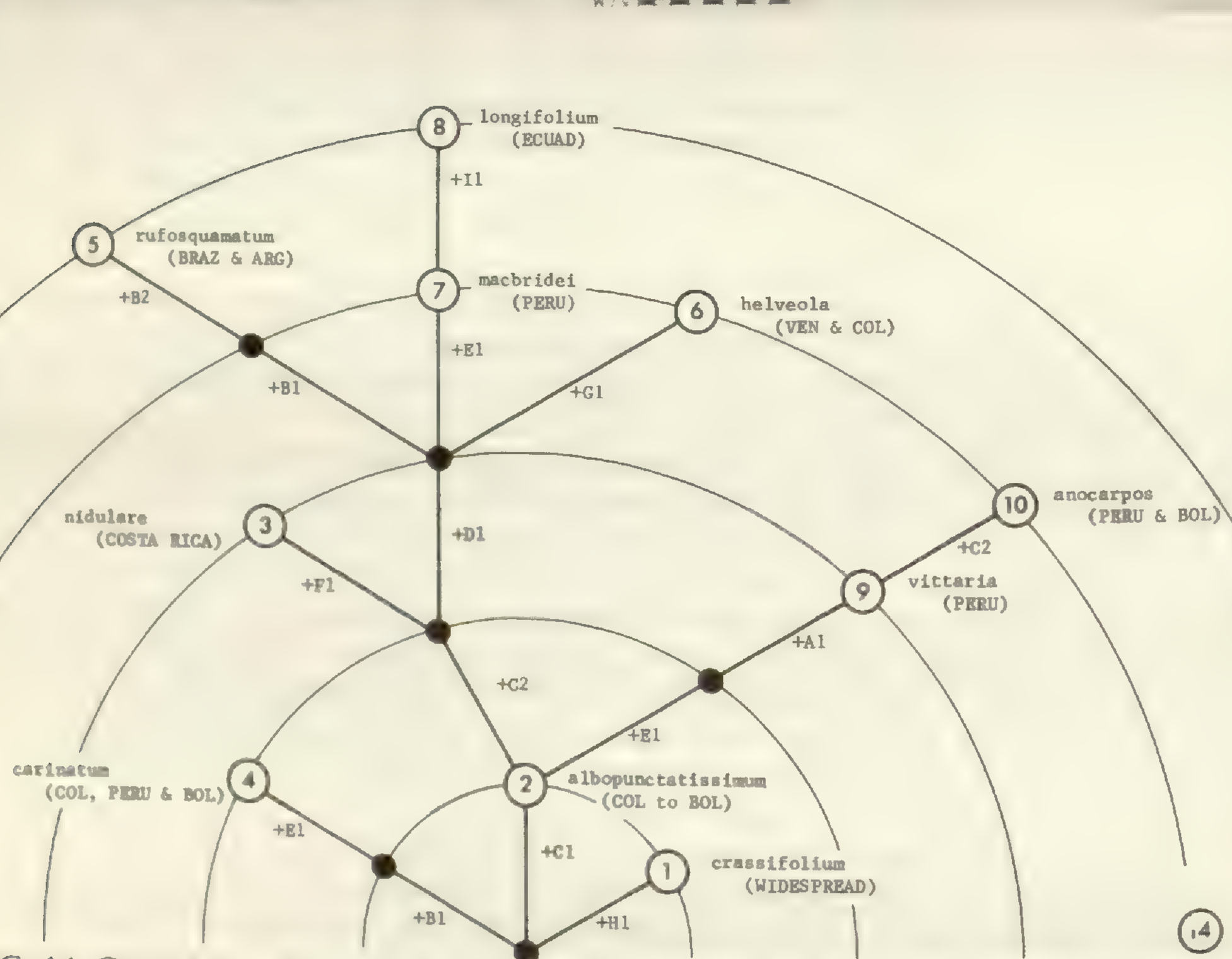


FIG. 14. Ground plan diagram of *Niphidium*. Explanation on pp. 101, 103. FIG. 15. Holotype of *Niphidium albopunctatissimum* (Williams 1062, NY).

RANGE AND HABITAT: Southern Colombia to southern Bolivia; in Peru and Bolivia mostly in the Cordillera Central and Cordillera Oriental. Terrestrial or epipetric, rarely epiphytic, at altitudes from (800)1800 m to 3300 m.

For comments on distinguishing *N. albopunctatissimum* from *N. crassifolium,* see the latter species. The pale green frond color may be due to bleaching in the strong sunlight of the exposed, terrestrial and epipetric habitat of this species, compared to the darker green fronds of the epiphytic *N. crassifolium,* which typically is at least partially shaded.

TABLE I. CHARACTERS OF EVOLUTIONARY IMPORTANCE IN *NIPHIDIUM*

Characters	*Characteristics*	1 *N. crassifolium*	2 *N. albopunctatissimum*	3 *N. nidulare*	4 *N. carinatum*	5 *N. rufosquamatum*	6 *N. mortonianum*	7 *N. macbridei*	8 *N. longifolium*	9 *N. vittaria*	10 *N. anocarpos*
A. Rhizome thickness	5–15 mm (0) 3–5 mm (1)	0	0	0	0	0	0	0	0	1	1
B. Rhizome scale color	bicolorous (0) weakly bicol. (1) concolorous (2)	0	0	0	1	2	0	0	0	0	0
C. Rhizome scale margins	entire (0) repand or erose (1) toothed or ciliate (2)	0	1	2	0	2	2	2	2	1	2
D. Rhizome scale cell walls	not contorted (0) contorted (1)	0	0	0	0	1	1	1	1	0	0
E. Lamina width	≧5 cm (0) <5 cm (1)	0	0	0	1	0	0	1	1	1	1
F. Lamina base	attenuate to acute (0) obtuse to rounded (1)	0	0	1	0	0	0	0	0	0	0
G. Sporangium pedicels	not swollen (0) swollen (1)	0	0	0	0	0	1	0	0	0	0
H. Paraphyses in sori	few or none (0) many (1)	1	0	0	0	0	0	0	0	0	0
I. Lamina scales	absent or rare (0) abundant (1)	0	0	0	0	0	0	0	1	0	0

ADDITIONAL SPECIMENS EXAMINED:

COLOMBIA: Putumayo: E Slope of Cerro San Francisco, N fork of Río Afiladores, 2500 m, *Ewan 16254* (US). **Nariño:** Pasto, ca 2500 m, *Espinosa E-2756* (US). **ECUADOR: Carchí:** Between Cunquer and Cuesaca, 2650–2900 m, *Acosta Solís 10455* (F). **Pichincha:** Cerro Antisana, 2 mi SE of Borja, 5700 ft, *Grubb et al. 1198* (US); Mt. Pichincha, 2800 m, *Mille* in 1920 (US). **Tungurahua:** Mera, 1400 m, *Schimpff 664* (F); Vicinity of Patate, Hacienda Leito, 2650 m, *Asplund 8030* (US); Baños, 6000 ft, 6 Feb 1921, *Popenoe* (US); Mt. Tungurahua, 2000 m, *Rimbach 393* (F). **Chimborazo:** Eastern Riobamba, Chamba,

2800 m, *Schimpff 792* (F, MO). **Cañar:** Near the village of San Marcos, 5–8 km NE of Azogues, *Camp E-2600* (NY, US). **Azuay:** Vicinity of Cuenca, *Rose 22840* (GH, NY, US); Mountains above Sayaus, E of Cuenca, ca 300 m, *Correll E-362* (US); Cruz Pamba region above Baños, ca 15 km SW of Cuenca, 9000–10000 ft, *Camp E-3949* (NY, US); Páramo Alpacada, along the Pan-American Highway 82 km S of Cuenca, 9500 ft, *Wiggins 10815* (MO, NY, US). **Loja:** Km 25 along the road from Loja to San Lucas, 2200 m, *Dodson & Thien 562* (MO, US). **PERU: Piura:** Ayabaca, 2742 m, *Soukup 4355* (US). **Cajamarca:** Huambos, 2000 m, *Soukup 4487* (US). **Amazonas:** Middle and upper slopes of Puma-urcu, SE of Chachapoyas, 2500–2700 m, *Wurdack 553* (F, US); Caño Santa Lucia just E of Chachapoyas, 2200–2300 m, *Wurdack 742* (GH, NY, US). **San Martín:** 60 km NE of Tingo María, at the pass through Cerro Azul on the Tingo María–Pucallpa Road, 1500 m, *Tryon & Tryon 5265* (GH). **La Libertad:** Near Chaullacocha, on the Trujillo–Otuzco Road, 8000 ft, *Saunders 897* (GH). **Huánuco:** 2–4 km E of Huasahuasi, 2400–2500 m, *Hutchison 1124* (F, US); Near Huasahuasi, below Tarma, 2600 m, *Correll & Smith P-773* (GH); Puacartambo, 2800 m, *Woytkowski 6746* (US); Carpapata, *Künkel 531* (GH); Between Palca and Carpapata, 2900 m, *Stork* [2nd U. C. Bot. Gard. Exped.] *10960* (F, UC, US); Manto, 29 km W of Yaupi, 1100 m, *Woytkowski 6552* (US); Huacapistana, between Tarma and San Ramón, 1800 m, *Constance & Tovar 2255* (UC); Villa Amoretti, *Künkel 527* (GH); Tingo María, Río Huallaga, *Asplund 12352* (US); Carpish, 2800 m, *Coronado 58* (GH, UC); 15 mi NE of Huánuco, ca 10000 ft, *Macbride & Featherstone 2148* (F, US); Mito, ca 9000 ft, *Macbride & Featherstone 1387* (F, US); Muña, ca 7000 ft, *Bryan 676* (US); Huacachi, estación near Muña, ca 6500 ft, *Macbride 4081* (F, US). **Huancavelica:** Chuspi-Tocas, between Colcabamba and Paucarbamba, 2800 m, *Tovar 2123* (GH). **Cuzco:** Between Mistiana and Keros, Valley of the Cosuipata, ca 800 m, *Scolnik 885* (US); Intihuatana, 1800 m, *Herrera 881* (US); Río Urubamba, 2050 m, *Angulo 1785* (GH); Hacienda Amaibamba, 1650 m, *Scolnik 802* (US). **Puno:** Near Tabina, *Lechler 2042* (LE). **BOLIVIA: La Paz:** Near Soratá, Río Challasuyo, 2650–2750 m, *Mandon 1566* (GH, LE, NY); Soratá, 7500 ft, *R. S. Williams 1061* (NY, UC, US); Tusihuaya, Chulumani, Yungas, ca 1740 m, *Scolnik & Luti 515* (US); Yungas, 6000 ft, *Rusby 345* (F, MICH, NY, US); North Yungas, Milluguaya, *Buchtien 5002* (US). **Cochabamba:** Incacorral, 2350 m, *Steinbach 9687* (F, GH, MO, NY); Road to Todos Santos near Comercocha, 300 m, *Cárdenas & Cutler 7376* (GH); Incachaca, 2500 m, *Steinbach 5785* (F, GH, MO). **Santa Cruz:** Cerro Hosána, 1900 m, *Steinbach 3401* (GH); Cordillera de Tucahuasi, 1700 m, *Cárdenas 2862* (F). **Tarija:** Caripata, *Bang 2142* (LE, MICH, MO, NY, US).

3. Niphidium nidulare (Rosenst.) Lellinger, comb. nov. Fig. 3.

Polypodium crassifolium var. *nidulare* Rosenst. Repert. Sp. Nov. Fedde **22:** 18. 1925. TYPE: La Palma, Prov. San José, Costa Rica, 1400 m, 14 Mar 1909, *A. & C. Brade 113* (S-PA Morton photos 5969, 20635 US; isotopes B photos NY, US).

Rhizomes short-cheeping, 6–9 mm in diam, not pruinose, phyllopodia 1–2 mm long, 3–5 mm wide; rhizome scales lanceolate-attenuate, 6–8 mm long, 2.5–3 mm wide, plane throughout, weakly bicolorous, the central band blackish, the cells strongly clathrate, those above the base 1.5–3 × longer than wide, the margins brown, shallowly toothed, up to 0.5 mm wide at the base, 0.05 mm wide toward the apex, the cells elongate toward the apex. Stipes 0.5–1 cm long, 3–5 mm in diam, adaxially flattened or sulcate. Laminae narrowly lanceolate, the juveniles lanceolate, attenuate or not much narrowed below to an obtuse or rounded base, acute at the apex, (25)55–105 cm long, 3–6.5(9) cm wide, dark green above in life, brown and not glaucous above when dry, with inconspicuous hydathodes, slightly paler beneath; midrib scales not observed; principal veins (3)5–7(9) mm distant, closer in partially developed fronds; sori round or slightly elongate transversely, 2–3 mm in diam; sporangia with up to 5 deciduous, linear, 1-celled hairs on the capsule; paraphyses (abortive sporangia) rare among the sporangia.

RANGE AND HABITAT: Cordillera Central of Costa Rica. Epiphytic, at altitudes of 1300–1550 m.

This species is most closely related to *N. crassifolium* and *N. carinatum,* from which it is distinct in its toothed, blackish rhizome scales and in its fronds, which have an obtuse to rounded base with almost obsolete stipes.

ADDITIONAL SPECIMENS EXAMINED:

COSTA RICA: Puntarenas: Monteverde, *de la Sota 5004* (LP). **Alajuela:** Zarcero, *A. Smith 48/199* (US); Region of Zarcero, *A. Smith F-40* (F). **San José:** Vicinity of La Palma, 1450–1550 m, *Maxon 454* (US). **Cartago:** Navarro, 1500 m, *Torres R. 42* (US); La Fortuna, between Cervantes and Pacayas, 1400 m, *Biolley 23* (US); Between Turrialba and Cartago, 21 June 1874, *Hb. Kuntze* (NY); Orosi, ca 5000 ft, *Scamman 6162* (GH); Estrella, 4400 ft, *Cooper 6046* (US).

4. Niphidium carinatum Lellinger, sp. nov. Figs. 4 and 16.

Ab *N. crassifolio* in squamis involutis rhizomatis, cellulis non valde clathratis, et in laminis angustis, usque ad 5.5(7.5) cm latis differt.

Rhizomes short-creeping, 6–8(10) mm in diam, not pruinose, phyllopodia 5–6 mm long, 3–4 mm wide; rhizome scales long lanceolate-acuminate, ca 8–10 mm long, 2.5 mm wide, carinate toward the apex, bicolorous, the central band brown to red-brown, the cells not strongly clathrate, the lumina obscured, those above the base 2–3 × longer than wide, the margins pale tan, entire toward the apex, slightly repand near the base, 0.5 mm wide at the base, ca 0.1 mm wide toward the apex, the cells elongate toward the apex. Stipes obsolete to 5 cm long, 2–3 mm in diam, adaxially sulcate. Laminae linear-lanceolate, the juveniles nearly linear, attenuate at the base, acute to rounded at the apex, 35–65(75) cm long, 2–5.5(7.5) cm wide, dark green above in life, brown above when dry, with small, brown or whitish, usually inconspicuous hydathodes, paler beneath; midrib scales not observed; principal veins 4.5–6(8) mm distant, closer in partially developed fronds; sori round, 2–3(4) mm in diam; sporangia with up to 12 persistent, linear, 1-celled hairs on the capsule; paraphyses (abortive sporangia) absent among the sporangia.

TYPE: Hacienda Mercedes, Entrada a Cayumba, forested slope to river, Prov. Huánuco, Peru, 1020 m, *Mexia 8223* (UC; isotypes F, GH, MICH, MO).

RANGE AND HABITAT: Central Colombia; Peru to central Bolivia. Equally epiphytic or terrestrial, at altitudes from ca 700 to 1800 m.

This is the only species of the genus with involute—not plane—rhizome scales; the cells of the central band are only weakly clathrate and have occluded lumina.

ADDITIONAL SPECIMENS EXAMINED:

COLOMBIA: Tolima: El Líbano, around coffee farms, 1580 m, *García-Barriga 12216* (US). **Valle:** Cartago, *André 1954* (F, NY). **PERU: San Martín:** Hera near Moyobamba, 890 m, *Woytkowski* [4th U. C. Bot. Gard. Exped.] *35315* (UC). **Huánuco:** Muña, ca 2100 m, *Macbride 3964* (F); Confluence of the Monzon and Huallaga Rivers, near Tingo María, 700 m, *Stork & Horton* [2nd U. C. Bot. Gard. Exped.] *9502* (F, UC, US). **Junín:** Huacapistana, 1812 m, *Coronado 239* (GH, UC). **Ayacucho:** Aina, between Huanta and the Río Apurimac, 750–1000 m, *Killip & Smith 22775* (NY, US). **Cuzco:** Quillabamba, Potrero, 1200 m, *Coronado 128* (GH, UC). **BOLIVIA: La Paz:** North Yungas, Polo-Polo, near Coroico, 1100 m, *Buchtien 3537* (F, GH, UC, US); South Yungas, Callisaya, 1700 m, *Cárdenas 857* (GH).

FIG. 16. Holotype of *Niphidium carinatum* (Mexia 8223, UC). FIG. 17. Holotype of *Niphidium rufosquamatum* (Luederwaldt 1841, US).

5. Niphidium rufosquamatum Lellinger, sp. nov. Figs. 5 and 17.

Ab *N. crassifolio* in squamis rhizomatis concŏloris rufis differt.

Rhizomes short-creeping, (8)10–13 mm in diam, not pruinose, phyllopodia ca 5 mm long, 5 mm wide; rhizome scales lanceolate-acuminate, ca 7–15 mm wide, plane throughout, always concolorous, rufocastaneous, weakly clathrate, the central cells more clathrate than the marginal ones, those above the base 2–3 × longer than wide, the margins repand to erose to toothed, the cells somewhat contorted. Stipes obsolete to 2 cm long, 3–5(6) mm in diam, adaxially sulcate. Laminae lanceolate to narrowly lanceolate, attenuate at the base into a narrow ala 2–4 mm wide, acute to rounded (sometimes with a small, acuminate tip) at the apex, (40)50–90(105) cm long, (4.5)5.5–10(11) cm wide, dark green above in life, brown and often glaucous above when dry, with inconspicuous, brown or white hydathodes, paler beneath; midrib scales ca 1.5 mm long, 0.4 mm wide, like those of the rhizome, caducous, seldom seen; principal sterile veins 5–10 mm distant, fertile veins 2.5–4(5) mm distant, closer in juvenile and partially developed fronds; sori round, 2–3 mm in diam; sporangia lacking hairs on the capsule; paraphyses (abortive sporangia) absent among the sporangia.

TYPE: Hammonia, Est. Santa Catarina, Brazil, *Luederwaldt 1841* (US; isotype NY).

RANGE AND HABITAT: Southeastern Brazil and northeastern Argentina. Epiphytic, rarely epipetric.

The only certain character for separating this species from *N. crassifolium* is the concolorous rhizome scales. The lack of hairs on the capsule and paraphyses among the sporangia are not so certain, and may also characterize occasional specimens of *N. crassifolium.* The fertile veins being closer together than the sterile ones is much more marked than in *N. crassifolium,* which often—but not always—has them spaced identically in mature specimens. But immature specimens of *N. crassifolium* and those in which blade expansion was halted prematurely may exhibit the same vein distance dimorphism that is typical of fully mature *N. rufopunctatum.*

ADDITIONAL SPECIMENS EXAMINED:

BRAZIL: Rio de Janeiro: Serra dos Orgãos, *Luetzelburg 6456* (MICH); Nova Friburgo, *Dusén 1920* (US). **São Paulo:** Alto do Serra, *Wacket 130* (NY); Campos do Jordão, *Leite 3634* (A, GH). **Paraná:** Pato Branco, *Reitz 4692* (HBR). **Santa Catarina:** *Luederwaldt 21987* (NY); Rio dos Bugres, Caçador, 800 m, *Reitz & Klein 12862* (HBR, US); Serra do Espigão, Papanduva, 100 m, *Reitz & Klein 12675* (HBR, US); Joinville, *Schmalz 94* (S-PA), 5 m, *Schmalz 75* (F); Passo Rio Canoas, Anita Garibaldi, 500 m, *Reitz & Klein 14764* (US); Ilha de Santa Catarina, Sertão da Lagoa, *Rohr CC1043* (HBR, US); Alto Matador, 700 m, *Reitz & Klein 6824* (US). **Rio Grande do Sul:** Estacão São Salvador, Montenegro, *Sehnem 2065* (GH); São Leopoldo, *Rick 21* (GH), *Leite 1699* (GH), vicinity of São Leopoldo, *Eugenio 60* (NY); Morro das Pedras, *Reitz 178* (HBR, US); Santa Cruz, *Jürgens* [Ros. Fil. Austro-bras. Exs. 101] (GH, NY). **ARGENTINA: Misiones:** Gral. M. Belgrano, Route 14, *de la Sota et al. 6151* (LP, US).

6. Niphidium mortonianum Lellinger, sp. nov. Figs. 6 and 18.

Polypodium crassifolium f. *helveola* Rosenst. Mém. Soc. Neuchat. **5:** 45. 1913, *nom. nud.* BASIS: "Savane de Bogotá et l'auberge de Tambo," Depto. Cundinamarca, Colombia, ca 2300 m, *Mayor 49* (S-PA Morton photo 20637 US).

Ab *N. crassifolio* in squamis rhizomatis leviter bicoloribus fuscis irregulariter dentatis non ciliatis, cellulis sinuatis vel contortis differt.

FIG. 18. Holotype of *Niphidium mortonianum* (Ewan 15602, US). FIG. 19. Holotype of *Niphidium macbridei* (Macbride & Featherstone 1234, US).

Rhizomes (5)6–10 mm in diam, not pruinose, phyllopodia 1–2 mm long, 2–6 mm wide; rhizome scales lanceolate-attenuate, ca 8–12 mm long, 2–3.5 mm wide, plane throughout, essentially concolorous, all but the marginal cells dark brown, strongly clathrate, those above the base 2–4(6) × longer than wide, the margins pale brown, distinctly irregularly toothed, the teeth up to 0.25 mm wide at the base, obsolete toward the apex, the cells contorted. Stipes (3)7–14 cm long, 2–4(5) mm in diam, adaxially flattened or sulcate. Laminae linear-lanceolate, the juveniles almost linear and with obsolete stipes, acuminate to attenuate at the base, acuminate, acute, or occasionally rounded at the apex, 35–75(100) cm long, (1.75)3–7.5 cm wide, dark green above in life, brown above when dry with inconspicuous brown or rarely whitish hydathodes, not paler beneath; midrib scales up to 2 mm long, 1 mm wide, like those of the rhizome, caducous, seldom seen; principal veins 3–6 mm distant, closer towards the apex than the base of the lamina in both juvenile and adult fronds; sori round, 2–3.5 mm in diam; sporangia occasionally with linear, 2-celled hairs on the capsule; apex of sporangial pedicels swollen and reddish; paraphyses (abortive sporangia) rare among the sporangia.

TYPE: Quebrada at end of Avenida 20 Julio trolley line, Bogotá, Depto. Cundinamarca, Colombia, 2640 m, *Ewan 15602* (US).

RANGE AND HABITAT: Northeastern Venezuela (Monagas); Northwestern Venezuela to southern Colombia. Epipetric, on stone walls, and terrestrial, but rarely epiphytic, at altitudes of 1500–2200 m in eastern Venezuela and 2400–2800 m elsewhere in the range.

ADDITIONAL SPECIMENS EXAMINED:

VENEZUELA: Monagas: Cerro Negro above La Sabana de las Piedras, NW of Caripe, 1500–2180 m, *Steyermark 62053* (F, US). **Mérida:** Near Colonia Tovar, *Fendler 222* (GH, MO, US); Mucurubá, 2600 m, *Gehriger 279* (F, NY, US). **Distr. Fed.:** "Folda de El Avila," *Ll. Williams 10936* (F). **COLOMBIA: Norte de Santander:** Hoya de Samaria, Cordillera Oriental, 2000–2100 m, *Cuatrecasas, Schultes & Smith 12780* (F, GH). **Cundinamarca:** Facatativa, *Ariste-Joseph A188* (US); On road to Usme ca 5 km SW of Bogotá, ca 2800 m, *Smith & Idrobo 1318* (US); Railroad station at Tablanca, 40 km WNW of Bogotá, 7000–7400 ft, *Little & Little 9145* (US); Salto de Tequendama, 2500 m, *Cuatrecasas 145* (F); Vicinity of El Salto, 8100–8300 ft, *Little & Little 7869* (US); Sueva Valley, 9 km W of Junín, 2400 m, *Grant 9094* (US); 7 km NW of Sibate, 2530 m, *Tryon & Tryon 6090* (GH); Bosque del Acueducto, Usaquén, *Murillo & Rico 59* (NY); "El Recreo," Santandercito, *Murillo & Fayad 122* (NY); Chiquinquirá, 2500 m, *von Sneidern 5843* (GH, MICH, MO); Along the Río Blanco SE of Guasca, vicinity of Los Andes, 9300 ft, *Core 574* (US); S end, E side of Suba Hill, near Bogotá, *Schiefer 567* (GH); In the mountains near Bogotá, *Holton 33* (NY). **Antioquia:** Boquerón, *Daniel 623* (F). **Santander:** Vicinity of Charta, 2600 m, *Killip & Smith 18959* (GH, NY). **Nariño:** W slope of Volcán Doña Juana, 2800 m, *Ewan 16598* (US), **Unlocalized:** *Moritz* (GH); *Mutis 3212* (F, US).

7. **Niphidium macbridei Lellinger, sp. nov.** Figs. 7, 13 and 19.

Ab *N. crassifolio* in squamis rhizomatis pallidis irregulariter dentatis sparse ciliatis, cellulis isodiametris differt.

Rhizomes creeping, 5–10 mm in diam, pruinose, phyllopodia 2–5 mm long, 3.5–5 mm wide; rhizome scales broadly lanceolate-acuminate, with a long, uniseriate, filiform to contorted tip, ca 6–8(10) mm long, 2.5–3 mm wide, plane throughout, strongly bicolorous, the central band blackish, the cells strongly clathrate, the lumina very large and clear, those above the base 1–1.5 × longer than wide, the margins pale tan, irregularly toothed or ciliate, up to 0.5 mm wide at the base,

0.25 mm wide toward the apex, the cells near the margins contorted. Stipes (3)7–13(15) cm long, 2.5–4.5 mm in diam, adaxially sulcate. Laminae usually narrowly lanceolate, attenuate at the base, acute but slightly rounded at the apex (juveniles rounded at the apex), (20)30–50(70) cm long, (2.5)3.5–6.5 cm wide, pale green above in life, pale green above and not glaucous when dry, with inconspicuous, whitish hydathodes, not paler beneath; midrib scales up to 3 mm long, 0.5 mm wide, like those of the rhizome but concolorous, caducous, seldom seen; principal sterile veins 5–6.5 mm distant, fertile ones (2.5)4–6.5 mm distant, closer in juvenile and partially developed fronds; sori round, 2.5–3(4) mm in diam; sporangia lacking hairs on the capsule; paraphyses (abortive sporangia) absent among the sporangia.

TYPE: Yanahuanca, Depto. Junín, Peru, ca 10000 ft, *Macbride & Featherstone 1234* (US; isotypes F, GH).

RANGE AND HABITAT: Andes of Central Peru, at altitudes of 2500 to 3600 m. Epipetric.

The range and habitat of this species, which has inconspicuous hydathodes in 2(3) series, overlap those of *N. albopunctatissimum,* which has usually conspicuous hydathodes in 3(4) series. *Niphidium macbridei* is not paler below than above, as *N. albopunctatissimum* is.

ADDITIONAL SPECIMENS EXAMINED:

PERU: Huánuco: Panao, ca 2500 m, *Asplund 13619* (US); Between Cuzco and Machupichu, 20 May 1958, *Guarrera* (LP). **Junín:** Along main road below Palca, 2800 m, *Correll & Smith P-760* (GH). **Apurímac:** Trail between Huancarama and Abancay, 3600 m, *West* [1st U. C. Bot. Gard. Exped.] *3765* (MICH, UC). **Cuzco:** Ollantaytambo, ca 3000 m, *Cook & Gilbert 544* (US); Urubamba, *Soukup 158* (GH).

8. Niphidium longifolium (Cav.) Morton & Lellinger, Amer. Fern J. 61: 39, *t. 8, f. 1–2.* 1971. Fig. 8.

Polypodium longifolium Cav. Descr. 245. 1802. TYPE: Pelileo, near Mount Tungurahua, Ecuador, *Née* (MA seen by Christensen).

Polypodium americanum Hook. Sp. Fil. **5:** 54. 1864. SYNTYPES: Cuenca, Ecuador, *Jameson,* and Baños, Ecuador, *Spruce 5248* (both syntypes presumably K, not seen).

Niphidium americanum (Hook.) J. Smith, Hist. Fil. 99. 1875.

Niphobolus americanus (Hook.) Diels in Engl. & Prantl, Nat. Pflanzenfam. **1**(4): 325. 1899.

Cyclophorus americanus (Hook.) C. Chr. Ind. Fil. 198. 1905.

Cyclophorus longifolius (Cav.) C. Chr. Dansk Bot. Ark. **9**(3): 11. 1937.

Rhizomes long-creeping, 5–12 mm in diam, pruinose, articulate to the rhizome but without phyllopodia; rhizome scales lanceolate-attenuate, ca 7–10 mm long, 1.5–2 mm wide, plane throughout, essentially concolorous, the central area reddish brown, the cells weakly clathrate, those above the base 1–3(4) × longer than wide, the margins paler and less clathrate, ciliate-toothed, the cells contorted, the cilia up to 1 mm long, the cells elongate toward the apex. Stipes (2)5–15(18) cm long, 1.5–2.5(3) mm in diam, adaxially sulcate. Laminae linear-lanceolate, the margins usually revolute at maturity, attenuate at base and apex, 35–60(65) cm long, 1–2.5(3) cm wide, dark yellow-green to bluish green above in life, greenish or brownish when dry, with small, usually conspicuous, dark brown or whitish hydathodes, densely scaly beneath on the lamina but not the midrib; laminar scales up to 4 mm long, 3 mm wide, like those of the rhizome except the central, clathrate portion reduced and the long, tangled, marginal cilia longer, always persistent; principal veins 4–6 mm distant, closer in juvenile and partially developed fronds; sori slightly to definitely elongate transversely be-

tween the veins, 1.5–3.5 mm long; sporangia rarely with up to ca 4 deciduous, linear, 1- or 2-celled hairs on the capsule; paraphyses (abortive sporangia) rare among the sporangia.

RANGE AND HABITAT: Andes mountains of Ecuador. Epipetric at altitudes of 2300–2900 m.

This species is the only one of the genus with the laminae beneath copiously and persistently scaly. Because the extremely long cilia on the scales slightly resemble the truly stellate hairs of *Pyrrosia* (formerly called *Cyclophorus*), this species has been put in that genus, but it is not at all allied (see Morton, C. V. and D. B. Lellinger, Amer. Fern J. **61:** 37–39. 1971). An infusion of the rhizomes is used as a purgative in intestinal infections and disorders (Ecuador, *Camp E-2487*).

ADDITIONAL SPECIMENS EXAMINED:

ECUADOR: Carchí: Between Cunquer and Cuesaca, 2650–2900 m, *Acosta Solís 10458* (F). **Imbabura:** Hacienda La Victoria, near Ibarra, 2350 m, *Mexia 7427* (US). **Imbabura–Pichincha:** Otavalo to Malchinguí, 2400–3000 m, *Hitchcock 20817* (US). **Pichincha:** At Cotocollas, *Mille 402* (US); near Cotocollas, 2750 m, *Mille* in 1920 (US); Quito, *Sodiro* (US). **Tungurahua:** Around Quero, Pelileo, etc. in the high mountain valley of Ambato, 1900–2700 m, *Lehmann 5036* (US); Between Pasa and San Fernando, 3000–3270 m, *Acosta Solís 8717* (F); Road from Ambato to Pillaro, ca 2700 m, *Scolnik & Chico 1580* (US); Zamanga at Ambato, 2700 m, *Böcher, Hjerting & Rahn 88* (US); On road to Ambato, 7 km from Baños, *Correll E-309* (US). **Chimborazo:** Chambo, *Asplund 6000* (US); Río Chambo, 2800 m, *Schimpff* (F, US); Riobamba, July 1912, *Mille* (US). **Cañar:** Near the village of San Marcos, 5–8 km NE of Azogues, *Camp E-2487* (F, US). **Azuay:** Around Cuenca, 2400–2900 m, *Lehmann 5729* (F, US); Vicinity of Cuenca, *Rose, Pachano & Rose 22816* (US); Cuenca, 2500 m, *Penland & Summers 1041* (US); Near Paccha, 2500 m, *Haught 3340* (US); Valley of the Río Tarqui a few km S of Cuenca, ca 2500 m, *Giler 59* (US).

9. Niphidium vittaria (Mett.) Lellinger, comb. nov. Figs. 9 and 11.

Polypodium vittaria Mett. Fil. Lechl. **1:** 8. 1856. TYPE: "Ad muros," Tabina, Prov. Puno, Peru, July 1854, *Lechler Pl. Peruan. 2039* (B-Hb. Mett. not seen Berlin photo 3504/2 US; isotypes L, W).

Rhizomes long-creeping, (2.5)3–5(6) mm in diam, not pruinose, phyllopodia 3–5 mm long, 1.5–3 mm wide; rhizome scales lanceolate-acuminate, patent, ca 4–8 mm long, 2–3 mm wide, plane throughout, strongly bicolorous, the central band dark reddish brown to black, the cells strongly clathrate, those above the base 1(2) × longer than wide, the margins nearly stramineous to pale tan, erose or slightly irregularly ciliate, up to 0.5 mm wide at the base, 0.05 mm wide toward the apex, the cells not elongate toward the apex. Stipes (3)5–10 cm long, 1–2 mm in diam, adaxially sulcate. Laminae linear-lanceolate, attenuate at the base (acute in juveniles), attenuate or rarely rounded at the apex, 30–50 cm long, 1.5–2(2.4) cm wide, probably pale green above in life, pale green or pale brown when dry, with black or white-encrusted hydathodes, not paler beneath; midrib scales up to 3 mm long, 1 mm wide, like those of the rhizome, persistent; principal sterile veins 5–6.5 mm distant, fertile ones 3.5–5 mm distant; sori round or rarely slightly elongate transversely in the largest specimens, 1.5–2.5(3.5) mm in diam; sporangia very rarely with up to 5 linear or slightly clavate (1)2-celled hairs on the capsule; paraphyses (abortive sporangia) rare among the sporangia.

RANGE AND HABITAT: Eastern Andes of central and southern Peru. Epipetric or occasionally epiphytic, at altitudes of (1200) 1500–2600 m.

ADDITIONAL SPECIMENS EXAMINED:

PERU: Huánuco: Muña, ca 7000 ft, *Macbride 3964* (US). **Junín:** Yaupi, 1580 m, *Woytkowski 6496* (MO, US). **Cuzco:** Potrero, 8 km W of Quillabamba, 1200 m, *Tryon & Tryon 5392* (F, GH, UC); Riberta del Río Urubamba, 2350 m, *Angulo 1755* (GH). **Puno:** Below Ollachea, 2520 m, *Vargas C. 6905* (UC).

10. Niphidium anocarpos (Kunze) Lellinger, comb. nov. Figs. 10 and 12.

Polypodium anocarpos Kunze, Linnaea **9:** 40. 1834. TYPE: "[In] truncis arborum ad Pampayaco," Depto. Huánuco, Peru, *Poeppig 1128* (LZ, destroyed; lectotype, chosen here: the isotype at B-Hb. Mett. not seen, Berlin photo 1504/5 US fragment US).

Polypodium acrosorum Kunze, Linnaea **9:** 39. 1834. TYPE: "In truncis arbor. vetustis sylvar. fl. Peruv. ad Pampayaco," Depto. Huánuco, Peru, July 1829, *Poeppig 1112* (LZ, destroyed; lectotype, chosen here: the isotype at HBG, photo US; isotypes BR, HBG, L, LE). The isotypes I have seen seem to be the same collection, although those at BR, HBG, and L are dated 1830, presumably erroneously, for they are an exact match for the one dated 1829. The specimen at L is labeled "Polypodium anocarpos." All but the one at L lack rhizomes; it alone is positively identifiable as *P. anocarpos,* principally through two badly eroded scales attached to the stipe base.

Phymatodes acrosora (Kunze) Presl, Tent. Pterid. 197. 1836.

Rhizomes long-creeping, (2)3–5(6) mm in diam, not pruinose, phyllopodia 2–4(5) mm long, 2–3 mm wide; rhizome scales broadly lanceolate, appressed, ca 2–2.5 mm long, 1.5–2 mm wide, plane throughout, strongly bicolorous, the central band black, the cells strongly clathrate with small, occluded lumina, those above the base 1(2) × longer than wide, the margins reddish brown to pale tan, fimbriate, usually erose in age, up to 0.5 mm wide at the base, 0.1 mm wide toward the apex, the cells not elongate toward the apex. Stipes (2)4–13 cm long, 1.5–2 mm in diam, adaxially sulcate. Laminae linear-lanceolate, attenuate or acuminate at the base, attenuate at the apex, (25)50–75 cm long, (1)1.5–3.5(4.5) cm wide, pale to dark green above in life, brown and sometimes glaucous above when dry, with brown, inconspicuous hydathodes, usually paler beneath; midrib scales up to 1.8 mm long, 0.8 mm wide, like those of the rhizome except the margins narrower and less fimbriate, persistent; principal veins 4–5.5 mm distant; sori round, 1.5–2.5(3) mm in diam; sporangia with up to 5 persistent, linear, 1-celled hairs on the capsule; paraphyses (abortive sporangia) rare among the sporangia.

RANGE AND HABITAT: Eastern Andes of Peru and Bolivia. Epiphytic or occasionally epipetric at altitudes of (1100)1400–3900 m.

The epithet *acrosorum* seems never to have been used other than by Kunze, and so I choose to adopt the epithet *anocarpos,* which occasionally is seen on herbarium specimens. It is surprising to find that Kunze named the same species twice in a single publication, for he rarely fell into such inaccuracy. In this case, the type of *P. acrosorum* has somewhat aberrant, curved-caudate fronds ("apice in acumen curvum"), which led Kunze to believe it was different from his *P. anocarpos.* The other characters adduced by Kunze are insubstantial, and the rhizome scales are apparently identical.

ADDITIONAL SPECIMENS EXAMINED:

PERU: Huánuco: Muña, ca 7000 ft, *Macbride 3975* (F, US), *4041* (F, US); Tambo de Vaca, ca 13000 ft, *Bryan 675* (US). **BOLIVIA: La Paz:** Hacienda Carano on the road to Tipuani, 1400 m, *Buchtien 7076* (NY, UC); Polo-Polo near Coroico, 1100 m, *Buchtien* [Ros. Fil. Bol. Exs. 125] *3528* (F, S-PA, UC, US); Coroico, *Bang 2447* (NY, US). **Santa Cruz:** Samaipata, 1800 m, *Steinbach 3758* (GH); Comarapa, Yungas de San Mateo, 2800 m, *Steinbach 8442* (F, MO), 2900 m, *Steinbach 8471* (GH), *8547* (MO).

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Page 80, Table 1, line 9. For "var. muricata" read "var. muricata (Dur.) Engelm."

Statement of Ownership, Management and Circulation

In accordance with the rules and regulations of the United States Post Office, as established under the act of October 23, 1962, Section 4369, Title 39, United States Code, the following statements are published.

Title: AMERICAN FERN JOURNAL

Frequency of Issue: Quarterly (Approximately March 31, June 30, September 30, and December 31)

Location of Office of Publication (Printers): 3200 Falls Cliff Rd., Baltimore, Maryland 21211

Location of Business Office of Publishers (Not Printers): Robert G. Stolze, Field Museum of Natural History, Chicago, Ill. 60605

Publisher: AMERICAN FERN SOCIETY, INC., Field Museum of Natural History, Chicago, Ill. 60605

Editor: Dr. David B. Lellinger, Department of Botany, Smithsonian Institution, Washington, D. C. 20560

Managing Editor: None.

Owner: AMERICAN FERN SOCIETY, INC., Field Museum of Natural History, Chicago, Ill. 60605

Bondholders, Mortgagees and other Security Holders: None

	Average No. each issue during preceding 12 months	Single issue nearest to filing date
Total number of copies printed:	1225	1200
Paid circulation		
1. Sales through dealers, etc.	0	0
2. Mail subscriptions	1004	1049
Total paid circulation	1004	1049
Free distribution, including samples	0	0
Total distribution	1004	1049
Office use, left-over, etc.	221	151
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AMERICAN FERN JOURNAL

Volume 63

1973

PUBLISHED BY THE AMERICAN FERN SOCIETY

EDITORS

Gerald J. Gastony

David B. Lellinger

John T. Mickel

Ira L. Wiggins

MERCURY PRESS, ROCKVILLE, MARYLAND 20852

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AMERICAN FERN JOURNAL

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Number 1
January–March, 1973

QUARTERLY JOURNAL OF THE AMERICAN FERN SOCIETY

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The "American Fern Journal" is an illustrated quarterly devoted to the general study of ferns. It is owned by the American Fern Society, and published at 3200 Falls Cliff Rd., Baltimore, Md. 21211. Second-class postage paid at Baltimore.

Matter for publication and claims for missing numbers (made within six months of the date of issue) should be addressed to the Editor-in-Chief.

Changes of address, applications for membership, subscriptions, orders for back numbers should be addressed to the Treasurer.

Subscriptions $5.50 gross, $5.00 net (agency fee $0.50); sent free to members of the American Fern Society (annual dues, $5.00; sustaining membership, $10.00; life membership, $100.00). Extracted reprints, if ordered in advance, will be furnished to authors at cost, plus postage.

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Additions and a Deletion to the Fern Flora of Missouri

JAMES S. KEY and PAUL L. REDFEARN, JR.*

Asplenium montanum.—A specimen of *Asplenium montanum* Willd. from Montgomery County, Missouri was recently discovered in the herbarium of the University of Missouri, Columbia. Collected by Frederick Dunlap, now deceased, the herbarium sheet (UMO 24754) label reads as follows: "*Asplenium ? montanum*. Montgomery Co.: Ravine to Loutre in south wall of canon at Cascade 26-48-6W. Dec. 4, 1960."

On one of our collecting trips in Montgomery County we met a Mrs. Darnell, who is known in her area as a person interested in the plants, birds, and history of her county. She remembered Mr. Dunlap collecting ferns on her property "ten or eleven years ago" and recalled his telling her he had found a fern that to his knowledge had never before been found in Missouri. Mrs. Darnell recognized the collection site he described as the huge sandstone boulder known locally as "fern rock" or "split rock." We searched "fern rock" (and quite an area in the vicinity) carefully but were unable to find *A. montanum*. "Fern rock" is located in Section 27 rather than in Section 26 as given on the collection label, so Section 26 was also carefully searched. We feel the label Section number is incorrect in that Section 26 has little in the way of south walls, poor fern habitats in general, and its ravine does not lead as directly into the Loutre River as does the ravine of Section 27. These topographic features together with Mrs. Darnell's recollection of Mr. Dunlap's description to her of his collection site cause us to feel strongly that we found the proper station, but the *A. montanum* may no longer be present or is indeed very rare. The 1960 collection could be an example of isolated occurrence, or perhaps the construction of an Interstate Highway close to the presumed station has in some way been responsible for the fern's disappearance.

Although Mr. Dunlap put a question mark before the specific epithet, the specimen is typical of published descriptions of *A. montanum* Willd. and is identical to specimens from other areas with which it was compared. It has been examined by Donald R. Farrar and Warren H. Wagner, Jr., both of whom confirm its identity as *A. montanum* Willd. The numerous Appalachian relationships of the Ozarks area flora make its presence not entirely unexpected. It constitutes a new record for the fern flora of Missouri.

Dryopteris celsa.—Wagner (1969) has noted that *Dryopteris celsa* (Palmer) Small is sometimes misidentified as *D. clintoniana*. A 1938 collection from Carter County, Missouri (*Steyermark 5333*, MO) identified as *D. clintoniana* (D. C. Eaton) Dowell var. *australis* Wherry, annotated as *D. celsa* (Palmer) Small by Wagner in 1971, represents such a misidentification. A comparison of this specimen with other *D. celsa* collections and with published descriptions supports Wagner's annotation. *D. celsa* should therefore be added to the flora of Missouri,

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Volume 62, number 4, of the Journal, pp. 97–124, was issued December 29, 1972.

and since the only record of *D. clintoniana* was based on misidentification, this taxon should be excluded.

The key to the genus *Dryopteris* in "Flora of Missouri" (Steyermark, 1963) will not lead to *D. celsa.* The spinulose teeth of *D. celsa* (though sometimes poorly developed) will most likely cause it to be confused with *D. austriaca* (Jacq.) Woynar. *D. celsa* may be separated from this taxon by its pinnate-pinnatifid blade, oblong-lanceolate pinnae, and broadly acute to rounded segments, characteristics not present in *D. austriaca.* If the spines are so obscure as to be missed, it must be separated from *Dryopteris goldiana* (Hook.) Gray. The broader base, smaller size, long acuminate pinnae, and once-forked veins of *D. celsa* will help to distinguish it. The innermost basal segment of the basal pinnae is shorter than the adjacent segment in *D. goldiana,* a feature not seen in *D. celsa.*

Asplenium rhizophyllum f. auriculatum.—*Asplenium rhizophyllum* L. f. *auriculatum* Hoffman was collected in Christian County on October 6, 1972 (*Key 1119*). All but one of the plant's eight leaves showed some degree of auricle formation; the longest auricles measure 31 and 34 mm. The plant was one of two with auriculate leaves growing in the midst of many typical plants on a moist limestone outcrop. No record of a previous reporting of the auriculate form from Missouri can be found. The specimen is deposited in the herbarium of Southwest Missouri State University, Springfield.

LITERATURE CITED

STEYERMARK, J. A. 1963. Flora of Missouri. Iowa State University Press, Ames.

WAGNER, W. H., JR., FLORENCE S. WAGNER and D. J. HAGENAH. 1969. The Log Fern Dryopteris celsa and Its Hybrids in Michigan—A Preliminary Report. Mich. Bot. **8:** 137–145.

Growth Patterns of Five Species of Lycopodium[1]

RICHARD B. PRIMACK*

Descriptions of the type and rates of growth of the lycopods have not been included in several recent studies of *Lycopodium* (Cardillo, 1970; Kukkonen, 1967; Bierhorst, 1971; Wilce, 1965). Wilce seems to have given the most attention to periodicity, for she says, "In arborescent and usually tufted species, determination of the age of the main upright axis is a simple matter of counting the number of seasonal 'leaf rings.' These leaf rings mark the retardation or cessation of growth at the end of each season; with their small, crowded leaves, they might be compared to an angiosperm bud, but with the difference that the leaves of the lycopodiaceous 'bud' are persistent." (However, she did not report observing annual "leaf rings" on the rhizome of *L. flabelliforme*.)

Colonies of five species of *Lycopodium* (*L. lucidulum* Michx., *L. annotinum* L., *L. flabelliforme* (Fern.) Blanch., *L. clavatum* L., and *L. obscurum* L.) growing at the Harvard Forest, Petersham, in central Massachusetts, were examined to determine their growth patterns and growth rates. Descriptions of the arrangement of the aerial shoots and rhizomes were made in the field. Measurements of annual growth of the aerial shoots and rhizomes were made in the laboratory on fresh specimens brought in from the field. The annual growth of the rhizomes of *L. flabelliforme, L. clavatum,* and *L. annotinum* was determined by locating the distinct microphyll compressions on the rhizome where the rhizome tip slowed down and then ceased growing in the fall and winter. Annual growth of aerial shoots can be determined in all species by noting the microphyll compressions on the shoot and branchlet axes.

My observation that there are annual, externally visible microphyll compressions on the rhizomes of *L. annotinum, L. clavatum,* and *L. flabelliforme,* seems to be an original one. In *L. annotinum* the actively growing rhizome has straight microphylls, which are 5 mm long and 0.8 mm wide, spaced 13 mm apart. In late fall, the curved microphylls, which are about 7 mm long and 0.7 mm wide, are spaced 5 mm apart. In *L. clavatum* the actively growing rhizome has microphylls which are about 4 mm long and 0.8 mm wide at the base, spaced about 8 mm apart. In late fall the microphylls, which become longer and narrower (to 8 mm long and 0.5 mm wide), are spaced about 1.5 mm apart. In *L. flabelliforme* the shape of the microphylls does not change, but during active growth the rhizome microphylls are about 16 mm apart, whereas they are only 2 mm apart toward the end of the season.

Lycopodium annotinum, L. clavatum, and *L. flabelliforme* have well-differentiated strobili and grow by a superficial rhizome just below the leaf litter. *Lycopodium annotinum* has a sessile strobilus and leaves with aristate tips. *Lycopodium*

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[1] I wish to thank Dr. J. M. A. Swan, Dr. Rolla M. Tryon, Dr. Alice F. Tryon, and Dr. Carroll E. Wood, all of Harvard University, for their generous suggestions and aid in reviewing the manuscript.

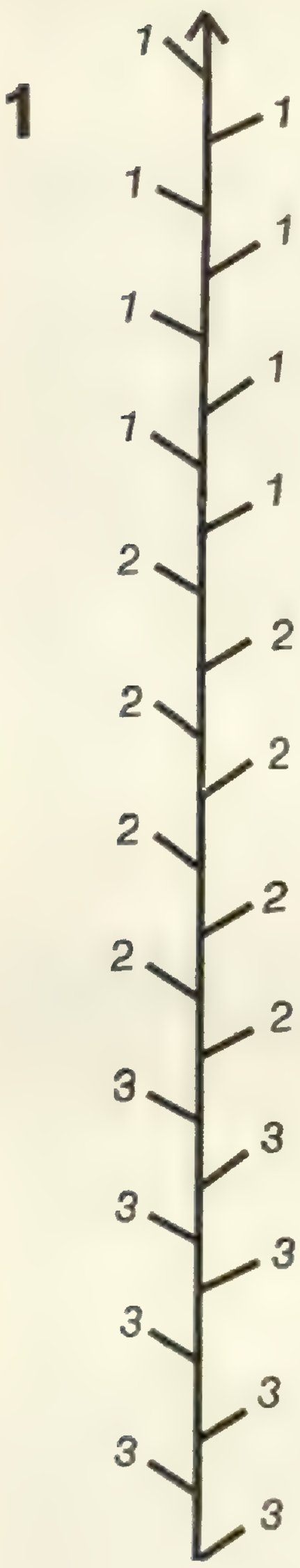
clavatum has peduncled strobili and leaves with long, hair-like tips. *Lycopodium flabelliforme* has dark green, flattened, fan-like branchlets. For ease of reference in the account that follows, the year in which an annual rhizome segment is laid down and the aerial shoots first initiated will be termed Year 1, the following year of growth of that segment will be Year 2, and so on. The rhizome of each species initiates aerial shoots during the same season the rhizome is growing. The average annual growth of the rhizome and the number of aerial shoots initiated for each species can be seen in *Table 1*. The aerial shoots arise by dichotomous, pseudomonopodial branching of the actively growing rhizome tip along a plane parallel to the surface of the ground, alternately to either side. This has the effect of creating two parallel lines of aerial shoots, one on either side of

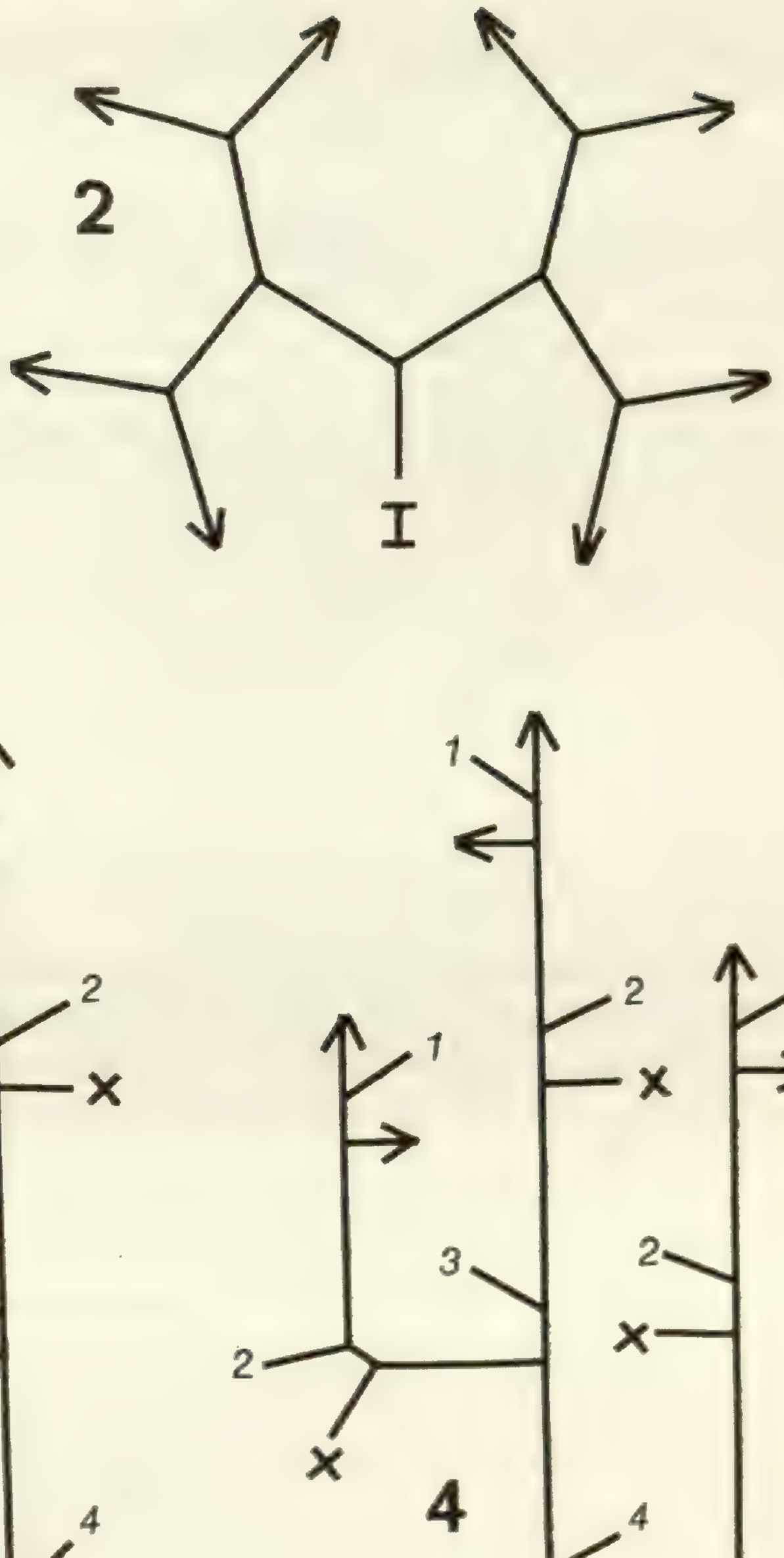
TABLE 1. SUMMARY OF GROWTH DATA FOR FOUR SPECIES OF *LYCOPODIUM*.

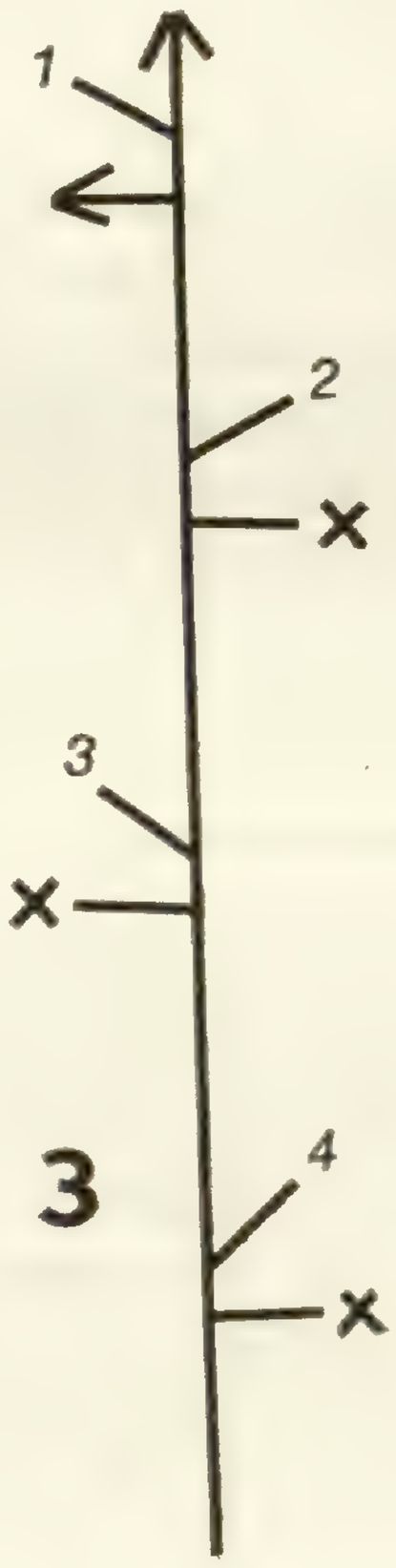
	flabelliforme	*clavatum*	*annotinum*	*obscurum*
Microphyll compressions on rhizome	yes	yes	yes	no
Average and range of annual rhizome growth (cm)	38 (26–50)	70 (48–103)	32 (22–45)	17 (13–21)
Average number and range of aerial shoots per year	9.3 (7–13)	12.8 (12–14)	7.9 (7–9)	1
Average distance between aerial shoots (cm)	4.0	5.6	4.0	17.4
Average length of aerial shoot at end of Year 1 (cm)	1.3	5	6.3	17.4
Range in length of mature aerial shoot without strobilus (cm)	12–18	4–9	11–22	18–23
Sample size for each measurement	20	20	20	15

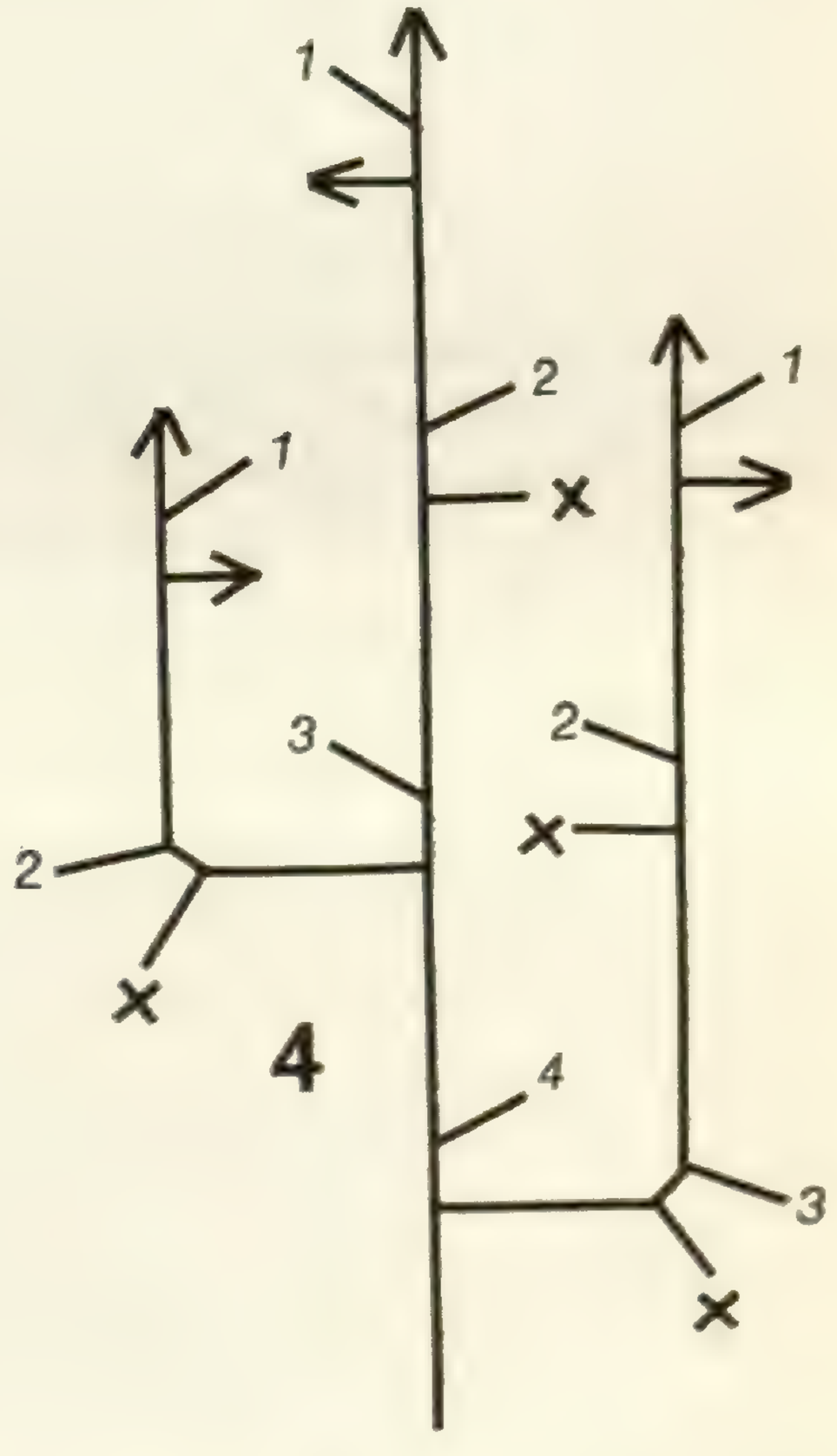
the rhizome (*Fig. 1*). At the end of Year 1, the aerial shoots closest to the rhizome tip are just tiny nubs that are barely discernible from the rhizome and are still below the leaf litter; the oldest shoots on the segment, which were initiated in the spring, may be as long as 7 cm. In Years 2, 3, 4, and 5 additional growth occurs on the aerial shoots, with the shoots finally attaining a length of 10–20 cm.

In all three species, strobili are generally produced in Year 4 or 5. The life span of most aerial shoots is four or five years, although some were observed to have died earlier. Occasionally a vigorous shoot will have a sixth year of growth. An aerial shoot may bend over and develop into a side rhizome, rather than continuing as an aerial shoot. In subsequent years the rhizome decays, with the result that the main rhizome and the side rhizomes become separate plants. This method of vegetative reproduction is the only means of reproduction I observed for these three species. No young sporophytes or gametophytes were found in the area where these species were observed.









Schematic branching patterns in *Lycopodium*. FIG. 1. *L. annotinum*, three year pattern. FIG. 2. *L. lucidulum*. FIG. 3. *L. obscurum*, four year pattern. FIG. 4. Same, vigorous plant. Arrow = rhizome apices; I = initiation point; x = dead side rhizome; 1, 2, 3, and 4 = first, second, third, and fourth year aerial shoots.

Lycopodium lucidulum is distinct from the other local Clubmosses in that it has no differentiated creeping rhizome. Furthermore, it lacks a definite strobilus, having instead alternating vegetative and fertile zones along the stem. *Lycopodium lucidulum* forms "fairy rings" up to two meters across.

New individuals of *L. lucidulum* may be produced vegetatively from gemmae that form in the upper leaf-axils of a large individual. All of the young plants observed were sprouting from these gemmae, never from gametophytes. The gemmae seem to be shed in the late summer or fall. In the spring of Year 1 a gemma sends a stem up above the leaf litter which has atypical, short, rounded microphylls. In all subsequent years the microphylls are elongated and sharp-pointed. After Year 1, the stem grows from 1.5 to 2.2 cm per year, with the apex dividing dichotomously every few years. This stem tip division seems to be synchronized in some way throughout the plant, since all the stem tips on a plant divide at approximately the same time. A twelve-year-old plant will commonly have eight or sixteen stem tips, which represent three or four stem divisions.

When the plant is about six years old, sporangia and their associated, large sporophylls are produced for the first time. The large sporophylls are produced early in the growing season, whereas the increasingly small vegetative microphylls are produced later in the season.

Every year the leaf litter that falls on the plant presses the stem toward the ground, decreasing the height. The 2 cm yearly growth of the stem compensates for this decrease in height and keeps the stem tips always about 8 cm above the leaf litter, and the divisions of the stem serve to spread the stem tips around in a circle (*Fig. 2*).

Lycopodium obscurum is readily distinguishable from the other local *Lycopodium* species by its truly underground rhizome that is buried an average of 6 cm and by its relatively tall, aerial shoots with arborescent branching.

The growth pattern of *Lycopodium obscurum* is not easily determined, since this species lacks microphyll compressions on the rhizome (*Table 1*). Many rhizomes were examined in May, 1971, and the most recently produced aerial shoot on each was always in the same stage of development. The aerial shoot was usually several centimeters long and directed upwards, although still below the surface of the ground, with the rhizome having continued horizontally about 6 cm beyond it. The second aerial shoot on each rhizome was two years old, as determined by its microphyll compressions, and the third aerial shoot was three years old. This is strong evidence that the rhizome only produces one aerial shoot per year. Since the average distance between aerial shoots on a rhizome is 17.4 cm, the average annual growth of the rhizome must be the same.

After the main rhizome of *L. obscurum* has grown several centimeters during the growing season, it sends off a weak side rhizome to one side by unequal dichotomous branching. The main rhizome continues for about 2 cm and again branches dichotomously in a plane parallel to the ground; the branch on the same side as the side rhizome develops upward into an aerial shoot, whereas the branch on the opposite side continues as the main rhizome (*Fig. 3*). This pat-

tern is repeated the following year with the side rhizome and the aerial shoot being produced on the other side of the main rhizome.

The weak side rhizome usually dies in Year 2, but occasionally in vigorous plants or plants with an injured main rhizome tip, it develops with its own side rhizomes and aerial shoots. A side rhizome initially grows at right angles to the main rhizome, but while initiating its first lateral rhizome and aerial shoot, the side rhizome turns 90 degrees and continues its growth parallel to the main rhizome (*Fig. 4*).

The growth patterns of the aerial shoots of *L. obscurum* can be determined easily by the prominent microphyll compressions along their length. In Year 1, the shoots arise by dichotomous branching of the rhizome. The shoots overwinter just below the surface of the forest floor. In Year 2, a rapid growth of up to 18 cm brings the shoots above the leaf litter. The branchlets of the shoots are held sharply upwards. In Year 3, the branchlets expand, with the shoots taking on their arborescent appearance. The branchlets may show slight additional growth, and the aerial shoots may develop sessile strobili during this year. In Year 4, the aerial shoots begin to wither and die.

The five species of *Lycopodium* examined showed different patterns of growth and different rates of growth. These differences may be important characters in distinguishing between species, as well as in understanding the relationships of each species to its environment.

LITERATURE CITED

BIERHORST, D. W. 1971. Morphology of Vascular Plants. Macmillian, New York.

CARDILLO, F. M. 1970. Stelar anatomy of six species of Lycopodium. Amer. Fern J. **60**(3): 89–97.

KUKKONEN, I. 1967. Studies on the variability of Diphasium (Lycopodium) complanatum. Ann. Bot. Fenn. **4:** 441–470.

WILCE, J. 1965. Section Complanata of the Genus Lycopodium. Nova Hedw. Beih. **19:** 1–233.

REVIEW

"THE FERNS AND OTHER PTERIDOPHYTES OF MONTANA, WYOMING, AND THE BLACK HILLS OF SOUTH DAKOTA," by Robert and Jane L. Dorn. 94 pp. 1972. Available from the authors, Department of Botany, University of Wyoming 82070. $1.00.—According to the introduction, "the primary purpose of this treatment is to provide an easy means for identifying the pteridophytes of Montana, Wyoming, and the Black Hills of South Dakota." The authors provide the kind of keys, descriptions, and limited synonymy that one expects to find in a manual. For each species they also provide a full page illustration showing habit, technical details, and known range within the area covered. In general they take a broad view of specific limits (e.g., *Polypodium vulgare*), and they do not pretend to provide any new insight into difficult groups. They have done a good job of what they set out to do.—*Arthur Cronquist, New York Botanical Garden, Bronx Park, Bronx, NY 10458.*

The Recent Discovery of Psilotum nudum in South Carolina

LAWRENCE F. SWAILS, JR.*

Psilotum nudum (L.) Palisot, a widespread member of the Psilophyta in tropical regions, has a limited distribution in parts of southeastern United States. Bold (1967, p. 268) lists it from Florida, Louisiana and Texas. According to Small (1938, p. 398), *Psilotum,* commonly called Whisk-fern, is not uncommon in parts of Florida and occurs north into South Carolina. Matthews (1941) states that *Psilotum* is apparently very rare in South Carolina, having been reported only from the following localities: Santee Canal, Berkeley County, *Ravenel* about 1847; Old neglected garden in South Carolina, *M. A. Curtis* in 1859; Bluffton, Beaufort County, *Mellichamp* in 1882, 1887, 1894. In 1954, Matthews found *Psilotum* on the Coker College Campus in Hartsville, Darlington County, South Carolina.

On December 30, 1971, on the grounds of a residence in Kingstree, Williamsburg County, South Carolina, I noticed a small plant growing under a *Camellia japonica.* After close observation, there was no doubt that the leafless specimen, which was about four inches long, was *Psilotum.* The unique features were dichotomous branching, small scale-like appendages (enations) on the aerial shoots, and the absence of roots. No sporangia were present. There were several much smaller shoots connected to the larger plant by a common rhizomatous system.

The larger specimen of *Psilotum* was taken with soil to the plant room in the biology department of Francis Marion College. It has continued to develop in a container with a two-foot palm under timed (twelve hours daily) fluorescent lighting. Several shoots have emerged from underground near the base of the aerial stem.

Apparently *Psilotum* does well associated with root systems of various monocots. In the greenhouse at the University of Cincinnati some years ago, the pteridophyte grew quite well at the base of large bananas and palms, as well as several other plants. The association with monocots is possibly due to a mycorhizal relationship.

The occurrence of this tropical or semitropical plant in such a "northern" region is probably due in part to the favorable climatic conditions during 1971. The early winter was very mild and the rainfall for the year was about 20 inches above normal. Hummingbirds frequent this garden spot and could possibly have brought the spore from which this *Psilotum* specimen developed.

LITERATURE CITED

BOLD, H. C. 1967. Morphology of Plants, ed. 2. Harper & Row, N. Y.

MATTHEWS, VELMA, 1941. The Ferns and Fern Allies of South Carolina. Amer. Fern J. **31:** 4–12.

SMALL, J. K. 1938. Ferns of the Southeastern States. 1964 reprint by Hafner, N. Y.

* Biology Department, Francis Marion College, Florence, SC 29501.

Tetrahedral Spores in Another Species of Lastrea[1]

PRAKASH CHANDRA*

The family Thelypteridaceae characteristically has monolete, bilateral spores with a well developed, variously folded perine. Trilete, tetrahedral spores have been reported so far in only one species of *Lastrea, L. ciliata* Hooker (Nayar & Chandra, 1966-67). Ching (1933), however, wrongly reported tetrahedral spores in the genus *Sphaerostephanos,* another genus of the Thelypteridaceae. During studies of thelypteroid ferns, I observed typically trilete, tetrahedral spores in *L. tenericaulis* Moore. The spores were studied from plants growing in the fernery of the National Botanic Gardens as well as from specimens collected in the Western Ghats of South India. In both cases, trilete, tetrahedral spores were mixed with bilateral ones and with some intermediate in form.

MATERIALS AND METHODS

The specimens studied are deposited in the herbarium of the National Botanic Gardens (*P. Chandra,* Nat. Bot. Gard. 96258 and 96259). Spore observations are based on acetolysed material and on fresh spores, both mounted in glycerine jelly. Spore measurements are based on 15 readings in each plane; the terminology follows that used by Nayar (1964).

OBSERVATIONS

The spores of *Lastrea tenericaulis* are generally monolete and bilateral (*Fig. 1*), as described earlier (Nayar & Chandra, 1965). A large number of trilete, tetrahedral spores occur mixed with the bilateral ones. The typical tetrahedral spores consist of a circular, subcircular, or triangular amb with broadly rounded corners and convex sides (*Figs. 4, 6, 7*). In lateral view the proximal half is roundly conical with the poles protruding; the distal half is hemispherical (*Figs. 5, 8*). The perine is granulose and sparsely wrinkled into thin, short, zigzag, or sinuous folds about 4μ tall. The exine is light brown and smooth. The laesura is about 32μ long and has the inner margin thickened. The spores average $44\mu \times 46\mu$ (E × P).

There are several intermediate spore forms between the monolete, bilateral and the trilete, tetrahedral ones. In the most common intermediate form, a third laesural arm just originates from the center of the main laesura (*Fig. 3*), pushing both ends downwards and thus giving it a trilete appearance (*Fig. 2*).

Fresh spores of *L. tenericaulis* contain many dense, yellowish-green plastids mixed with oil globules.

DISCUSSION

Lastrea tenericaulis is one of the primitive species of the Thelypteridaceae (Chandra, 1969). It is characterized by having a short, erect rhizome clothed with a dense mass of roots that form a stilt-like envelope around the rhizome; the rhi-

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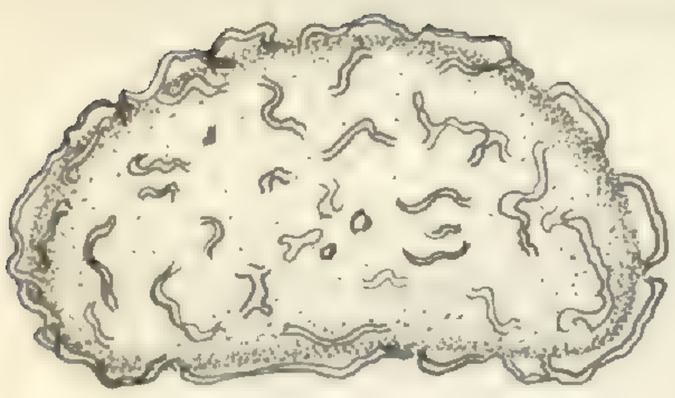
* National Botanic Gardens, Lucknow, India.

[1] Thanks are due to Prof. R. E. Holttum for his valuable suggestions and to my colleague Dr. Santha Devi for help in the spore study.



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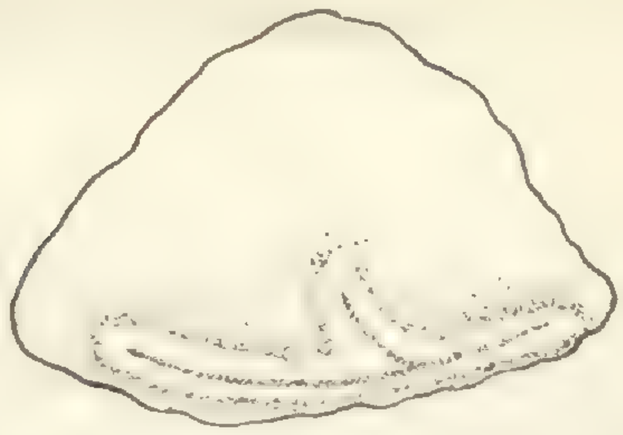

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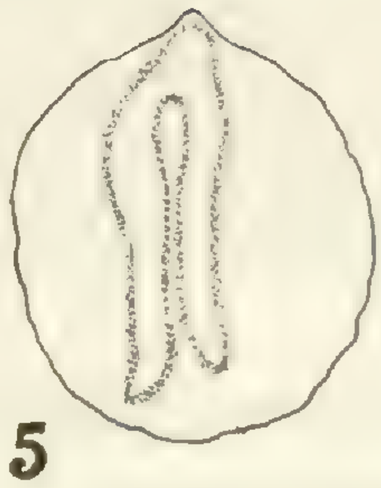

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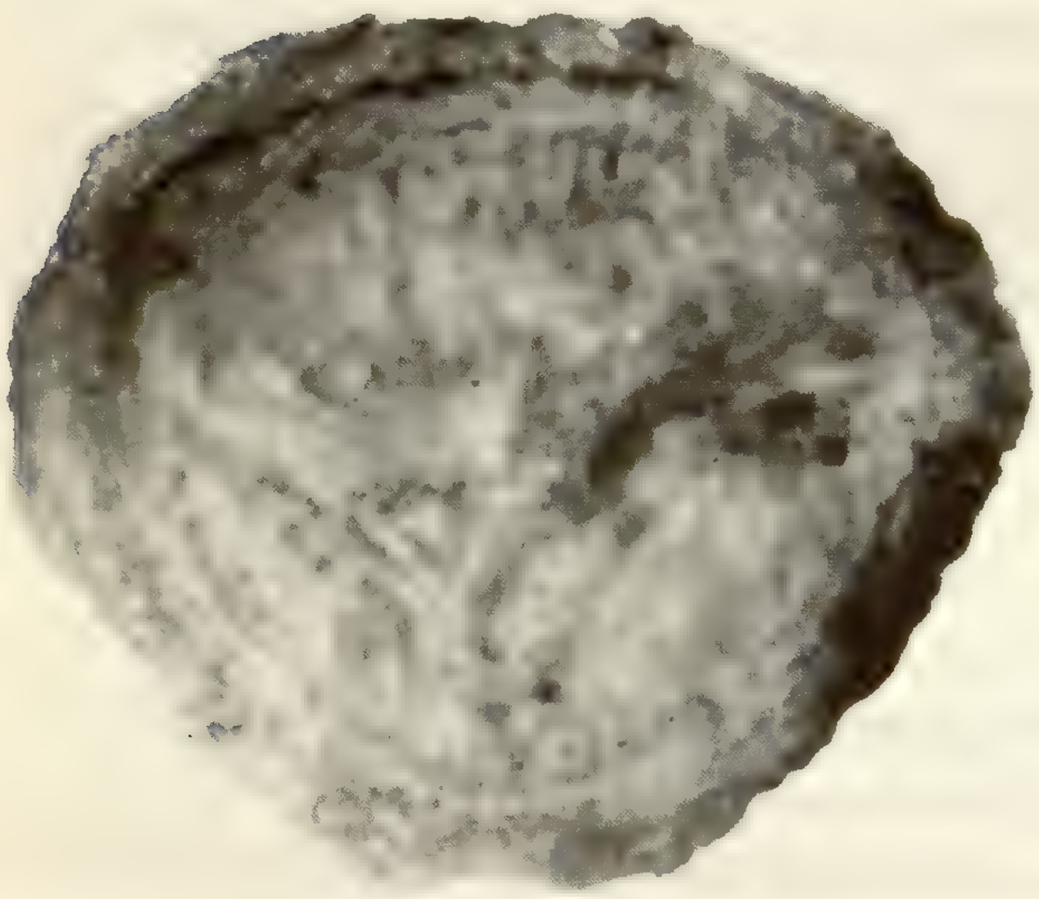

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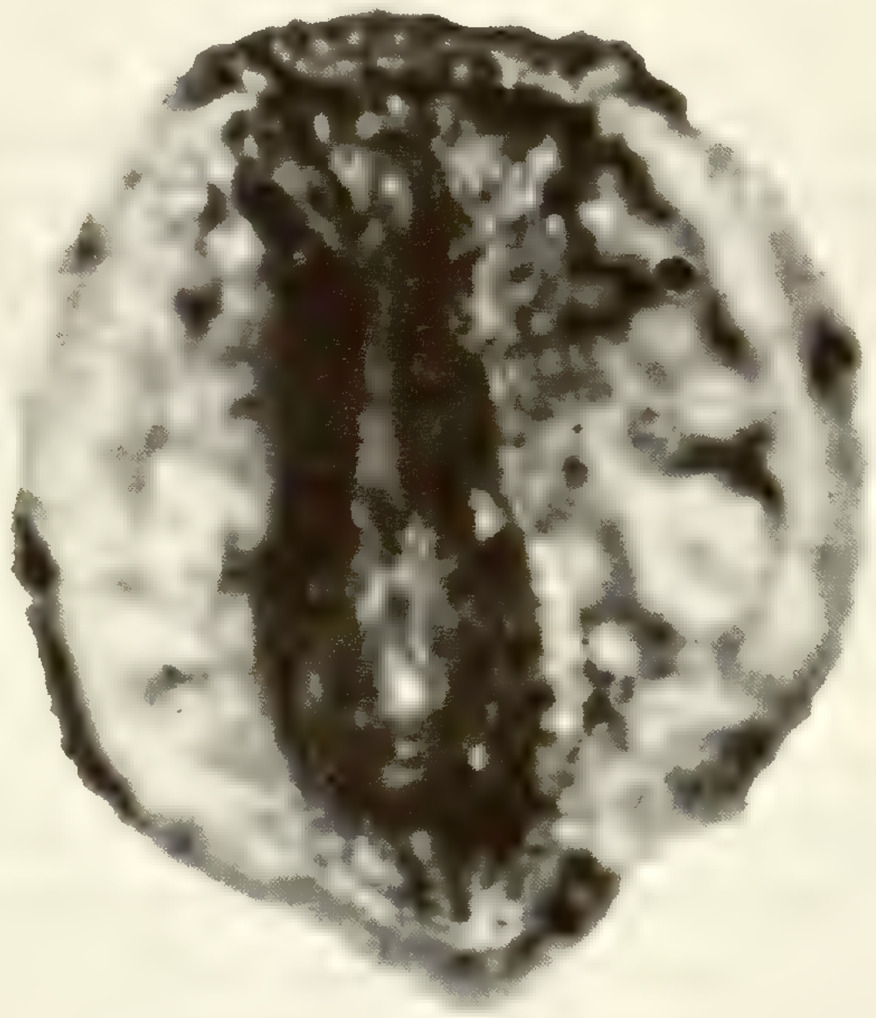

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Spores of *Lastrea tenericaulis*. Fig. 1. Bilateral spore, lateral view. Figs. 2–5. Trilete spores intermediate between tetrahedral and bilateral (diagrammatic). Fig. 6. Typical trilete spore, lateral view. Fig. 7. Trilete spore, proximal view. Fig. 8. Same, lateral view.

zome is devoid of sclerenchyma strands. The sori are circular and often have a small, caducous indusium. The sporangia are large and have a tendency for the annular ring to be interrupted, otherwise irregular, or sometimes oblique. The mixed spores are further evidence of primitiveness, as in the case of *L. ciliata.*

According to Holttum (1971, p. 19), the family Thelypteridaceae shows a close resemblance to the genus *Cyathea.* He further states that the "Thelypteridaceae look like somewhat simplified, more efficient, and more diversified relatives of *Cyathea,* and they are certainly in a very active state of development." However, the absence of trilete, tetrahedral spores in the Thelypteridaceae has been held as an important argument against the cyatheoid affinity of these ferns (Nayar & Chandra, 1965). The occurrence of trilete, tetrahedral spores in two primitive species of *Lastrea* is, therefore, of much significance and supports the postulated cyatheoid ancestry of the thelypteroid ferns.

LITERATURE CITED

CHANDRA, P. 1969. Morphological and phylogenetical studies on some Aspidiaceae. Ph. D. Thesis, Agra University.

CHING, R. C. 1933. On the nomenclature and systematic position of Polypodium Dryopteris L. and related species. Contr. Biol. Lab. Sci. Soc. China **9:** 30–43.

HOLTTUM, R. E. 1971. Studies in the family Thelypteridaceae III. A new system of genera in the Old World. Blumea **19:** 17–52.

NAYAR, B. K. 1964. Palynology of modern Pteridophyta. Advances in Palynology (ed. P. K. K. Nair). Lucknow.

————, and P. CHANDRA. 1965. Gametophyte of some species of Lastrea Bory. J. Indian Bot. Soc. **44:** 84–94

————, and P. CHANDRA. 1966–67. The occurrence of tetrahedral spores in a species of Lastrea (Thelypteridaceae). Palynological Bull. II & III: 92–95.

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Systematics of the Genus Ceratopteris (Parkeriaceae), I. Sexual and Vegetative Reproduction in Hawaiian Ceratopteris thalictroides

ROBERT M. LLOYD*

Ceratopteris Brongn., a genus of four species, is circumtropical in distribution and is restricted in habitat to aquatic situations such as ponds, streamsides, and other very wet areas (Lloyd, 1972). Frequently it is a weed in taro patches or rice paddies where frequent or continuous flooding is utilized in cultivation. In the Hawaiian Islands, the genus is represented by a single species, *C. thalictroides* (L.) Brongn., which today occurs almost entirely as a weed in taro patches on the islands of Oahu and Kauai.

Because of certain features of its biology, *C. thalictroides* is a unique species in which to study reproduction and genetics. These features include rapid gametophyte growth with production of a sporophyte with fertile fronds in about 3.5 months (Klekowski, 1970), an annual life-cycle of about 12 months' duration, and profuse vegetative reproduction by buds found on the blades of both sterile and fertile fronds. In addition, other features relating to reproductive phenomena include 32 very large spores per sporangium, a sporangial annulus which has lost much of its function in spore dissemination, and production of an antheridogen (Schedlbauer & Klekowski, 1972).

Ceratopteris thalictroides has evolved into a myriad of forms found in both the Old and the New World. In the region of the Pacific Ocean these forms frequently are restricted in distribution to specific islands or island groups. Those features of reproduction relating to spore dissemination and vegetative reproduction apparently have been instrumental in determining distribution patterns and the ability of a species to undergo long distance dispersal.

An analysis has been made of six Hawaiian populations of *C. thalictroides* of varying ages. Although the Taro patch habitat is artificial, because it can be dated it presents a unique opportunity to study the elements of reproduction within the species and to correlate these data with other features of its biology and evolution.

The first recorded observation of *C. thalictroides* in Hawaii was made apparently by H. L. Lyon, who reported to Wagner (1950) that when he first arrived in the islands in 1907 the species was much more common than it was 40 years later. Lyon believed that it was introduced to Hawaii by the Chinese, who either tolerated it along their irrigation ditches leading to their rice fields or actually cultivated it for food. As a food plant the species has been used by many different Oriental groups throughout the Pacific, including people from China, Japan, and the Philippines (Copeland, 1942). Because the species is a weed in rice paddies and taro patches throughout many areas of the Pacific, spores or vegetative buds could have been transported easily to Hawaii with the crops or

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foodstuffs of any of these peoples. The Hawaiian plants most closely resemble those found in Japan, and it is probably there that the original parent populations lie.

Herbarium specimens indicate that earlier in this century *C. thalictroides* was widespread on Oahu. It was collected first in the Kalihi Valley in 1919, then in the Manoa Valley in 1930 and 1934, at Waikane in 1934, and in the Kahaluu Valley in 1935. On Kauai, Wagner (1950) observed a large population in wet meadows and taro patches at the mouth of the Wainiha Valley and in the village of Hanalei, although at the latter location the plants were entirely sterile and at the bottom of a ditch under water.

The present distribution of *Ceratopteris* is more limited than it was in the past. Taro has ceased to be a commercial crop in all but a few locations, and many patches have been turned into pasture. On Oahu *C. thalictroides* is found in one small series of patches behind a house at 49-065 Kamehameha Highway, Waikane, in isolated stream and ditch areas just to the south, and in a very small, private taro garden on the leeward side of the island in the Wainaie Valley. On Kauai it has been collected only at Hanapepe in the south and in the Hanalei Valley in the north, although numerous other appropriate habitats exist on the island. On the other Hawaiian islands, specifically Maui and Hawaii, Taro is widely cultivated. However, *Ceratopteris* has not been collected nor observed in these localities; so far as is known it has always been restricted to Oahu and Kauai.

Due to the intensive weeding since 1968 at both Hanalei and Waikane and to the elimination of nearly half of the patches from the Hanalei Valley, the population of *Ceratopteris* has been drastically reduced. It is anticipated that elimination of this species from the Hawaiian flora is imminent.

In the Hanalei Valley, site of Populations A–E, cultivated crops including Taro have been grown since the arrival of the first Polynesians. After 1880, much of the land was developed by the Chinese into rice paddies. Handy (1940) reports that rice cultivation was continuous from the Hanalei River to about 1.3 miles west, although many people cultivated small plots of Taro for their own use. In the early 1950's Taro was first planted in the valley on a large scale, and has been cultivated nearly exclusively there since then. *Ceratopteris* has been recognized as a troublesome weed for only about five years, although it has been present in the vicinity since before 1947. Local growers report that the species just appears in the patches a few months following the planting of Taro.

The history of Taro cultivation at Waikane, site of Populations F–H, dates from 1951 when a weedy pastureland was converted into taro patches. The current grower has no knowledge of the first appearance of *Ceratopteris*, although he states that "it was a long time ago." Taro cultivation is similar to that at Hanalei.

The life-cycle of *Ceratopteris* follows closely that of Taro, both of which mature in approximately 12 months. After harvesting the mature Taro plants (12–15 months old), the fields are weeded and Taro is planted and periodically flooded to insure continuous water. Planting and harvesting are staggered throughout the area, and so all stages of maturation of Taro can be found at any time of year.

METHODS AND MATERIALS

Plots were selected at random in five Taro patches in the Hanalei Valley, Kauai, of varying ages of planting and maturation of Taro (*Colocasia esculenta*) and, consequently, *Ceratopteris*. Populations A–D were each of an area of one square meter. Population E, which had a much greater density of *Ceratopteris* plants, was one-half meter square. Data from the latter plot were adjusted by a factor of four to correspond in area with Populations A through D. At Waikane, Oahu, three plots in a single taro patch were chosen and sampled (Populations F–H). Of these, Population F is reported in detail; it consisted of ten areas each one square decimeter taken from separate locations within a one square meter area. Data from this population were adjusted by a factor of ten to correspond to one square meter.

Ages of the sampled populations are as follows: A, 3 months; B, 4 months; C, 5 months; D, 8 months; E, 10 months; F, 13 months; and G and H, 14 months.

Plots were sampled by collecting all plant material within the designated areas as well as the top layer of soil. This material was transported back to the laboratory where it was floated out and carefully segregated into size-classes. Smaller plants, usually those with stems less than 2.5 cm high, were examined to see whether they arose by sexual or asexual means. Plants of gametophytic origin possessed all stages of frond development and frequently were still attached to gametophytic tissue. Plants produced by vegetative budding lacked the first two developmental frond stages and in many cases were still attached to the parent frond. In many cases it was not possible to discern mode of origin; data in the tables include only those cases where mode of origin was clear.

POPULATION ANALYSIS OF CERATOPTERIS

Population A, the youngest sampled, shows a preponderance of individuals under 2.5 cm high, with over 73% of the entire population under 5 cm (*Table 1*). Although the number of individuals under 2.5 cm high gradually increases from Population A through D, the percentage representation of this size-class remains relatively constant (50 to 57%). It is interesting that all size-classes from Population A through D remain relatively constant in percent representation, whereas size-classes in Population E exhibit a bimodal distribution curve both for number of individuals per size-class and also for percent representation. In this population there is a decrease in the number of plants under 2.5 cm high (as compared with Population D), as well as an increase in plants over 15 cm high. In addition, the greater percent representation figures are found in these two size-classes. This trend toward a bimodal distribution pattern in size is continued in Population F, although here there is a large increase in the number of individuals both under 2.5 cm as well as over 15 cm high.

The total number of plants per population increases geometrically, from a low of 114 in Population A to a high of 4100 in Population F, with a doubling time of between two and three months. The bimodal trend as exhibited by Populations E and F indicates that most of the smaller plants have grown into the larger

size-classes (those over 15 cm high) and that numerous new individuals are being produced under 2.5 cm high.

Concurrent with the growth in numbers of plants is a change in coverage of *Ceratopteris* (*Table 2*). Younger populations (A–C) are characterized by large areas of bare soil. As populations mature and reach an age of 8 months (Population D), the soil surface becomes completely covered by plants of *Ceratopteris*. Coverage of Taro remains relatively constant (ca. 6%) in populations of various ages, with the exception of Population F, which was harvested prior to this study.

TABLE 1. NUMBER AND PERCENT OF PLANTS PER POPULATION BY SIZE CLASS.

Size Class	*Population*					
(cm)	A	B	C	D	E	F
Under 2.5	61 (53.5%)	70 (50.7%)	148 (57.6%)	592 (56.8%)	496 (27.0%)	950 (23.1%)
2.5 - 5.0	23 (20.1%)	34 (24.6%)	55 (21.4%)	164 (15.7%)	236 (12.8%)	150 (3.7%)
5.0– 7.5	9 (7.9%)	20 (14.5%)	23 (9.0%)	132 (12.6%)	232 (12.6%)	250 (6.0%)
7.5 10.0	11 (9.8%)	10 (7.2%)	20 (7.8%)	76 (7.3%)	176 (9.6%)	300 (7.4%)
10.0–12.5	4 (3.4%)	2 (1.5%)	7 (2.6%)	40 (3.8%)	144 (7.8%)	150 (3.7%)
12.5–15.0	5 (4.4%)	2 (1.5%)	2 (0.8%)	24 (2.3%)	180 (10.0%)	100 (2.4%)
15.0–30.0	1 (0.9%)		2 (0.8%)	16 (1.5%)	368 (20.0%)	850 (20.7%)
30.0–42.5					4 (0.2%)	1100 (27.0%)
42.5–60.0						250 (6.0%)
Total Plants	114	138	257	1044	1836	4100

Fertility of plants shows surprising changes with age. Younger populations (A and B) show fertile plants in the smaller size-classes with 100% fertility in individuals over 5 cm high (*Table 3*). As the populations age (C–F), fertility becomes delayed, and in Population F plants are not fertile until at least 7.5 cm high; 100% fertility is not reached until the plants are at least 12.5 cm high. Although fertility is restricted to the larger individuals in older populations, a greater percentage of plants are fertile in plots 10 or more months old as compared with younger populations (*Table 4*).

Relative to all of the characteristics of aging mentioned above is the change in mode of reproduction from sexual via spores and gametophytes to vegetative (*Table 5*). In Population A, over 75% of the individuals were produced by sexual reproduction. This figure remains fairly constant through Population D. However, in Population E there is a sudden drop to about 20% of the new plants being produced by sexual reproduction. This trend culminates in Population F, where all of the new individuals are produced by vegetative budding. Populations G and H, each 14 months old and sampled after harvest, continue this trend.

DISCUSSION

The pattern of population growth as exhibited by *Ceratopteris* is similar in many respects to the early stages of the logistic growth curve reported in many laboratory populations of animals, including ants, water fleas, flour beetles, bees,

TABLE 2. PERCENT COVER OF SPECIES PRESENT IN POPULATIONS A–F.

Species	*Population* A	B	C	D	E	F
Ceratopteris thalictroides	35.	40.	60.	94.	94.	99.
Colocasia esculenta	5.	5.	6.	6.	6.	0.
Other species	0.	0.	0.	0.	0.	1.
Bare soil	60.	50.	34.	0.	0.	0.

TABLE 3. PERCENT OF FERTILE PLANTS PER POPULATION BY SIZE-CLASS IN EACH POPULATION.

Size Class (cm)	*Population* A	B	C	D	E	F
Under 2.5	0.0	0.0	1.3	0.0	0.0	0.0
2.5– 5.0	30.0	61.7	32.7	31.7	28.8	0.0
5.0– 7.5	100.0	100.0	34.7	69.6	86.3	0.0
7.5–10.0	100.0	100.0	50.0	89.5	97.7	33.3
10.0–12.5	100.0	100.0	100.0	100.0	100.0	66.7
12.5–15.0	100.0	100.0	50.0	100.0	100.0	100.0
15.0–30.0	100.0		100.0	100.0	100.0	100.0
30.0–42.5					100.0	100.0
42.5–60.0						100.0

TABLE 4. NUMBER AND PERCENT OF FERTILE PLANTS PER POPULATION.

Plants	*Population* A	B	C	D	E	F
Total number	114	138	257	1044	1836	4100
Number fertile	37	55	48	292	1136	2500
Percent fertile	32.5%	40.0%	18.7%	28.0%	62.0%	61.3%

TABLE 5. NUMBER AND PERCENT OF SEXUAL AND ASEXUAL PLANTS PER POPULATION.

Mode of origin	*Population* A	B	C	D	E	F
Sexual						
Number of plants	16	12	19	180	56	0
Percent of total	76%	57%	68%	67%	20%	0%
Asexual						
Number of plants	5	9	9	88	228	800
Percent of total	24%	43%	32%	33%	80%	100%

and *Drosophila melanogaster* (Allee et al, 1949, p. 307). However, in the Hawaiian Taro patches maximum population size is apparently never reached, as growth curves still show geometric increases in the oldest populations at harvest and shortly before weeding of the fern. Of particular interest are the features which accompany population growth and maturation, specifically restriction of fertility to larger and older plants and elimination of reproduction by sexual means.

Young populations of *Ceratopteris* are characterized by large areas of bare soil. My observations indicate that gametophyte establishment takes place in these open areas, particularly when the water level lowers to the point where the ground is emergent, usually first near the base of the Taro plants. As coverage of the open soil increases, gametophyte establishment is restricted; in the oldest populations with full soil coverage, it is completely eliminated. It is of interest to note that antheridogen C, recently discovered by Schedlbauer and Klekowski (1972) in this species, would be most concentrated and probably most effective on these emergent soil areas in younger populations. Concurrent with the elimination of open soil by profuse plant growth is the rapid increase in vegetative reproduction from frond buds. In this species this becomes pronounced when both sterile and fertile fronds become senescent and fall to the surface of the soil, initiating bud development from the numerous initials located in the sinuses of the pinnae. Thus, reproduction within the *Ceratopteris* populations in Hawaii following initial establishment of gametophytes and subsequent maturation of the population appears to occur strictly by vegetative means.

Other features of the biology of *C. thalictroides* can be seen to coincide with its precinctive aquatic habitat (see Carlquist, 1966). These include a sporangial annulus which functions only in opening the sporangium, but without the characteristic features of snapping back into its original position, which has been interpreted as a mechanism for dissemination of spores. Frequently, sporangia do not open at all, but shatter easily when dry. In addition, the large (96–124μ) spores may float, lie suspended in the water, or sink immediately. The large spores and the vestigial functioning of the annulus can be interpreted as restricting spore dissemination, thus maximizing the number which remain in an environment favorable for survival. Rapid gametophyte growth and sporophyte production must also be considered here. Klekowski (1970) has found that cultures of *C. thalictroides* will become sexual in less than 20 days and that new sporophytes appear in 20 days following sowing. In addition, fertile sporophylls are produced in about 105 days. This rapidity in growth may relate to varying or seasonal water supply.

Genetic studies performed by Klekowski (1970) on Hawaiian *Ceratopteris* indicate that none of the sporophytes tested were heterozygous for sporophytic lethals. In addition, he found that these populations possess an intragametophytic mating system.

My morphological studies on the Kauai and Oahu populations show that there is no substantial difference in plants found on these two islands. From these results it is tempting to speculate that *C. thalictroides* was introduced to the Ha-

waiian Islands by a single propagule, probably perpetuated by intragametophytic mating and vegetative budding on one island, and subsequently introduced to the other. During the time that the species has existed in Hawaii there apparently has been little change morphologically or genetically in these populations. Since Hawaiian plants differ morphologically from all other populations of *C. thalictroides* and since numerous islands or island groups in the Pacific also exhibit similar differences, it is reasonable to suggest that these latter isolated populations have been established in a similar manner.

LITERATURE CITED

ALLEE, W. C., A. EMERSON, O. PARK, T. PARK, and K. SCHMIDT, 1949. Principles of animal ecology. W. B. Saunders, Philadelphia.

CARLQUIST, S. 1966. The biota of long-distance dispersal. III. Loss of dispersibility in the Hawaiian flora. Brittonia **18:** 310–335.

COPELAND, E. B. 1942. Edible ferns. Amer. Fern J. **32:** 121–126.

HANDY, E. S. C. 1940. The Hawaiian planter 1. His plants, methods and areas of cultivation. B. P. Bishop Mus. Bull. 161. Honolulu.

LLOYD, R. M. 1972. Species delineation in the genus Ceratopteris (Parkeriaceae). Amer. J. Bot. **59:** 676.

KLEKOWSKI, E. J., JR. 1970. Reproductive biology of the Pteridophyta, IV. An experimental study of mating systems in Ceratopteris thalictroides (L.) Brongn. Bot. J. Linn. Soc. **63:** 153–169.

SCHEDLBAUER, M. D. and E. J. KLEKOWSKI, JR. 1972. Antheridogen activity in the fern Ceratopteris thalictroides (L.) Brongn. Bot. J. Linn. Soc. **65:** 399–413.

WAGNER, W. H. JR. 1950. Ferns naturalized in Hawaii. Occ. Paps. B. P. Bishop Mus. **20:** 95–121.

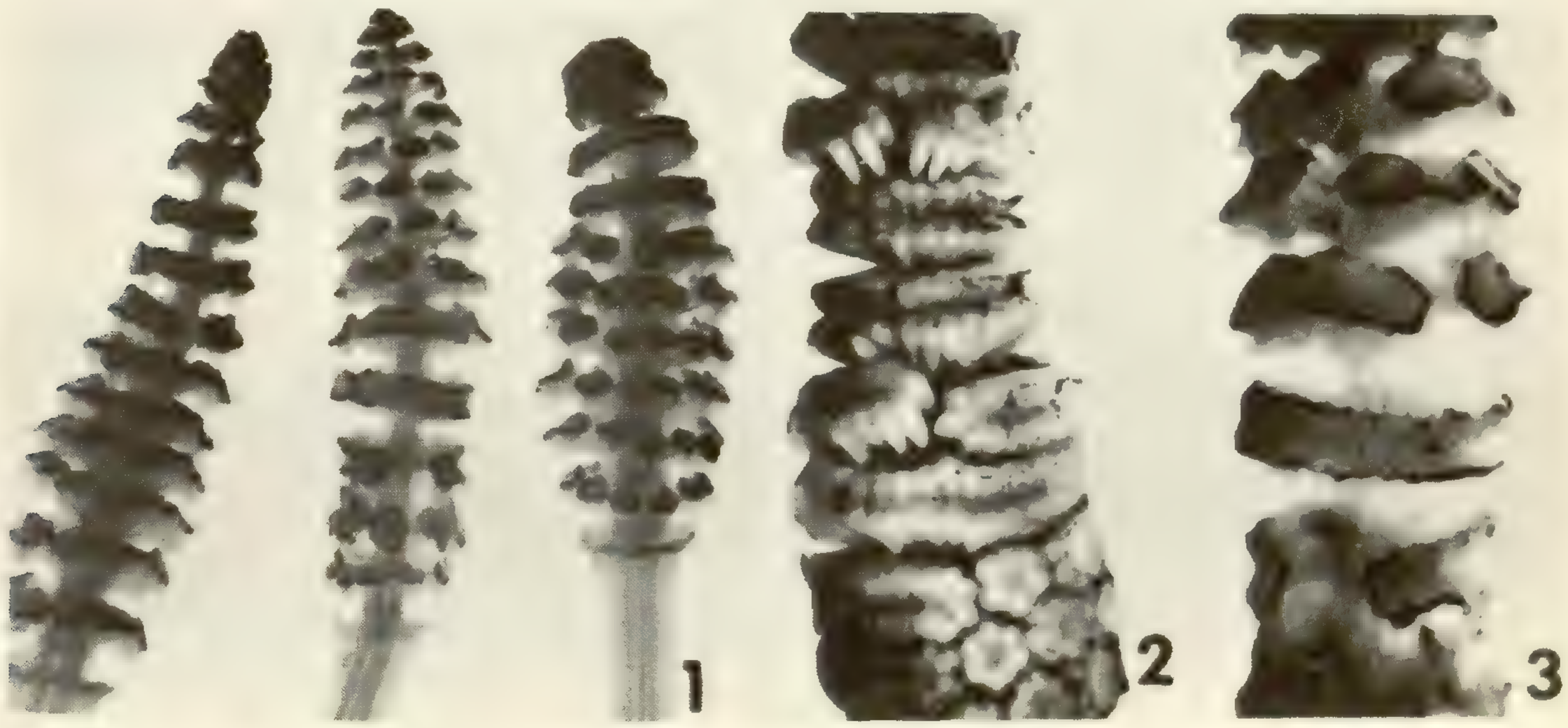
AMERICAN FERN JOURNAL

Manuscripts submitted to the JOURNAL are, in most cases, reviewed for scientific content by the editors alone. During the past year, however, we also have received the kind assistance of Drs. Richard L. Hauke, Robert M. Lloyd, John T. Mickel, Robert L. Peterson, Harold E. Robinson, and Richard A. White, which we acknowledge with thanks. Because of the increasing diversity of papers, we hope to expand our use of non-editorial board reviewers in this and following years, and would welcome suggestions or offers of assistance.—*D.B.L.*

Abnormal Strobili in a Stand of Equisetum arvense

TERRY R. WEBSTER*

Abnormal strobili in the genus *Equisetum* have been described by several authors (Kashyap, 1930; Schaffner, 1933; Tschudy, 1939; Sinha, 1956; and Hauke, 1970). The present account describes the occurrence, during two successive years, of abnormal strobili in a stand of *Equisetum arvense* L. The stand, covering approximately 1200 square feet, is adjacent to a small stream in an undeveloped portion of the University of Connecticut campus. During the springs of 1971 and 1972, abundant abnormal strobili were produced.



Figs. 1–3. Abnormal *Equisetum arvense* strobili exhibiting extensive fusion. Fig. 1, × 1.8. Fig. 2. Immature strobilus, × 3.8. Fig. 3, × 3.8.

The abnormal strobili exhibit extensive lateral fusion of sporangiophores, resulting, in extreme cases, in one or more rings completely encircling the strobilus axis (*Figs. 1–3*). The fusions include the sporangiophore stalks and peltate tips. Individual sporangia remain separate. Fusions were observed in strobili at various stages of development, including unexpanded dormant strobili collected in October. From the population of abnormal *Equisetum arvense,* 364 strobili were carefully examined. Forty-two (11.5%) strobili exhibited extensive fusions (ring-like structures), and 219 (60.2%) exhibited somewhat less extensive fusions (i.e., had three or more fused sporangiophores in at least two separate whorls of the same strobilus).

The author has found no previous report of the above-described abnormality for *Equisetum*. The occurrence of abnormal strobili in significant numbers in a single population during two successive growing seasons raises interesting ques-

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tions. Whether the fusions are the result of genetic or environmental change is unknown at this time, but continued observations will hopefully shed further light on the matter.

LITERATURE CITED

HAUKE, R. 1970. Terminology of the sporangial structures of Equisteum. Amer. Fern J. **60:** 162–163.

KASHYAP, S. 1930. Some abnormal cones in Equisetum debile. J. Indian Bot. Soc. **9:** 240–241.

SCHAFFNER, J. 1933. Six interesting characters of sporadic occurrence in Equisetum. Amer. Fern J. **23:** 83–90.

SINHA, S. 1956. Some abnormal cones of Equisetum debile Roxb. J. Indian Bot. Soc. **35:** 123–125.

TSCHUDY, R. 1939. The significance of certain abnormalities in Equisetum. Amer. J. Bot. **26:** 744–749.

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SHORTER NOTES

A TREE FERN CULTIVAR.—Of the thousands of tree ferns grown commercially in southern California, remarkably few variants have been developed. Some twenty years ago a very large and rapidly growing variant of *Alsophila cooperi* F. v. Muell. was named *Alsophila* 'Robusta' by Mr. A. W. Roberts, of the former Subtropical Gardens Nursery in Los Angeles. As this plant did not grow readily from spores, few plants reached the trade. Recently a new variant

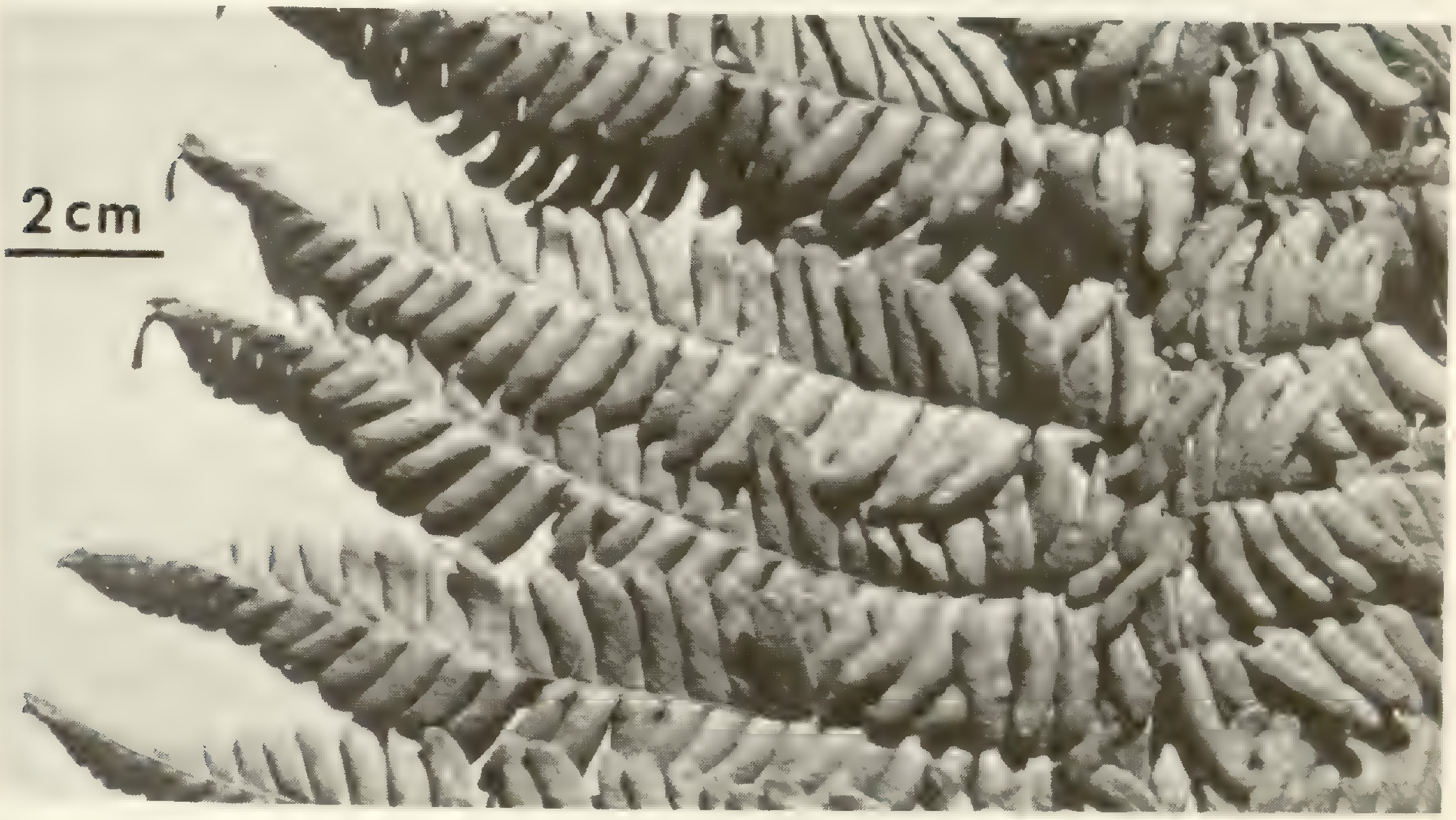

Fig. 1. Crowded, median pinnules and segments of *Sphaeropteris cooperi* cv. Brentwood (*Hoshizaki 17-11, LA*).

of this species has been introduced into the trade under the name *Alsophila cooperi* cv. Brentwood. It is a large, rapid grower with a full-foliaged appearance to the fronds, and it reproduces readily from spores. It was discovered among the nursery stock of the ABC Nursery, of Gardena, California and was initially grown by Mr. and Mrs. H. F. Woodley, of Brentwood, California. Dr. Rolla Tryon, Jr. kindly verified the species identification; recently he (Contr. Gray Herb. **200:** 24. 1970) transferred the species to *Sphaeropteris*. Therefore, the correct name of the cultivated variety is:

Sphaeropteris cooperi (F. v. Muell.) Tryon cv. Brentwood, cv. nov.

Fronds ca 2.2 m long, the stipe ca 1 m long, the blade ca 1.2 m wide and 1.2 m long, the secondary pinnae and segments often crowded and overlapping one another, the blades ca ⅓ larger than the species, and the growth rate ca ⅓ faster than the species.—*Barbara Joe Hoshizaki, Life Science Dept., Los Angeles City College, Los Angeles, CA 90029.*

AN UNUSUAL POPULATION OF ANTROPHYUM LANCEOLATUM.—All the genera of the family Vittariaceae normally have simple and entire blades, with the exception of *Hecistopteris,* which has fronds with a furcate apex. *Antrophyum lanceolatum* (L.) Kaulf., a member of this family, is a common epiphyte in the dense, wet forests of tropical America. Only very seldom does one find fronds of this species that show any evidence of segmentation. A population of

FIGS. 1–4. Unusual Fronds of *Antrophyum lanceolatum*

this fern was collected recently by Mr. and Mrs. John Taylor on the Atlantic slopes of Volcán Arenal, Costa Rica, at an elevation of 450 m (*Taylor & Taylor 11626,* CR). All the blades show some degree of pinnatisection (*Figs. 1–4*). This was not caused by external factors, but rather by some meristematic accident, perhaps of genetic origin, as evidenced by the presence of secondary costae in some of the blades (*Figs. 3–4*). Other diagnostic characteristics of the collection conform to typical *A. lanceolatum.*—*Luis D. Gómez P., Herbario Nacional de Costa Rica, Apartado 749, San José, Costa Rica.*

REVIEWS

"SYSTEMATICS OF THE ONOCLEOID FERNS," (Univ. Calif. Publ. Bot., vol. 61), by Robert M. Lloyd. 93 pp. 1971. University of California Press, Berkeley, CA 94720. $3.50.—A small group like the onocleoid ferns, consisting of only three genera *Onoclea, Onocleopsis,* and *Matteuccia,* the first two monotypic and the last one with three species, lends itself well to a systematic study such as

Dr. Lloyd has written. The major emphasis is on comparative morphology, including well-illustrated descriptions of the spores, gametophytes, gametangia, young sporophytes, and the mature sporophyte organs—root, rhizome, and frond. There are also some data from cytology and comparative chemistry (chromatography). Using the information from his systematic study, the author was able to argue convincingly that the three genera studied are closely related to one another and constitute a subfamily within the family Aspidiaceae. It was a pleasure to see the use of mean values as well as ranges for measurements in describing variation. The pleasure would have been greater had sample size and standard deviation or standard error also been given. Such information would enable the reader to evaluate the measurements better. The usage of the term "tier" in the description of the archegonial neck seems to me unclear. The author uses that term for the four axial rows of neck cells characteristic of fern archegonia. Since the neck is at an angle, not really vertical or horizontal, the term "tier," with its implication of a horizontal row, is best avoided. Another, more important, fault in this book can be found in the taxonomic section. That is the absence of an adequate citation of the types. *Onoclea sensibilis* and *Matteuccia struthiopteris* lack any mention of a type at all. Lectotypes are named for the other two species of *Matteuccia,* but insufficient information is given to enable me to judge the adequacy of the selected lectotypes. There are few typographical errors, but one particularly obvious one is the omission of the citation after the name *Forbes, E.* in the "Literature Cited" section. Another, at least I presume it was typographical, is the omission of the quotation marks around the genus name "*Aspidium*" on page 21 (this name is in quotes on the next page). To read a review such as this can be misleading since it appears more space is devoted to negative than to positive aspects of the work under consideration. Actually it is a scholarly work which for the most part is carefully done. Considering everything, I would say that this book is of value to professional pteridologists, at least in their university libraries, but is probably of less interest to the amateur pteridologist.—*Richard L. Hauke, Dept. of Botany, University of Rhode Island, Kingston, RI 02881.*

"LISTA DE LAS ESPECIES CUBANAS DE LYCOPODIOPHYTA, PSILOPHYTA, EQUISETOPHYTA Y POLYPODIOPHYTA (PTERIDOPHYTA)," by J. J. Duek. Adansonia II, **11:** 559–598, 717–728. 1971.—This is a list of the pteridophytes of Cuba, with some synonymy, an indication of the types of the species described from Cuba, but without any keys, descriptions, taxonomic comments, or statements of distribution within Cuba. It shows a good deal of study of the literature, but not much of the plants themselves. There are a number of errors. Species are listed that probably do not occur in Cuba or indeed anywhere in the West Indies, such as *Stigmatopteris caudata* (Raddi) C. Chr. and *S. ichtiosma* (Sodiro) C. Chr., while on the other hand some species that do occur in Cuba rather commonly, like *Antrophyum* [*Polytaenium*] *lineatum* (Swartz) Kaulf., are omitted. Some species are listed under two names, e.g., *Diplazium arboreum* (Willd.) Presl and *D. cristatum* (Desr.) Alston, which are synonyms, or *Elaphoglossum flaccidum* (Fée) Moore and *E. rigidum* (Aubl.) Urban, also generally

considered synonyms, in spite of the strangely contradictory specific epithets. The taxonomic disposition of some species is incorrect; thus *Anemia pastinacaria* Moritz is placed in subg. *Anemiorrhiza* although it really belongs in subg. *Anemia*. *Polypodium shaferi* Maxon is placed in *Polypodium,* but if *Xiphopteris* is segregated as a genus, as Duek does, then *shaferi* is a true *Xiphopteris* in every character, although it has not been transferred, because Copeland was not satisfied that it was truly different from *X. mitchellae*. The Gleicheniaceae is divided into the two genera *Gleichenia* and *Dicranopteris,* following Holttum, and this is eminently reasonable. However, Duek includes *D. bancroftii* (Hook.) Underw. in *Dicranopteris,* but if this is done it destroys all the generic characters of anatomy, scales, venation, and soriation of *Dicranopteris;* this peculiar species *bancroftii* is the only American representative of *Gleichenia* subg. *Diplopterygium* (Diels) Holttum (cf. Reinwardtia **4:** 261. 1957). And *Gleichenia bifida* (Willd.) Spreng. is included in subg. *Gleichenia* [which is properly restricted to the Old World species with minute ultimate segments], whereas it is an entirely typical species of the subg. *Mertensia*. The generic name *Gymnogramme* Desv. must be considered as a superfluous and consequently illegitimate name, and so this genus must be called *Eriosorus;* the species *G. cubensis* (Maxon) C. Chr. is considered by Dr. A. Tryon in her monograph of the genus (Contr. Gray Herb. **200:** 106. 1970) as a synonym of *E. hirtus* (H. B. K.) Copel.; it must be admitted that it is rather peculiar to find this continental species disjunct in eastern Cuba and nowhere else in the West Indies, but having an endemic but allied species there would be equally peculiar. Duek does not give any reason for adopting the later name *Thelypteris arcuata* (Poiret) Reed for the common species *T. patens* (Swartz) Small. The genus *Byrsopteris* Morton was unfortunately found shortly after it was published to be a synonym of the old genus *Arachniodes* Blume (cf. Tindale, Contr. New So. Wales Nat. Herb. **3:** 89. 1961). *Asplenium salicifolium* var. *krugii* Christ is placed as a synonym of *A. salicifolium* L., which would seem reasonable offhand except that Christ was using the name *A. salicifolium* in quite a different sense than that presently accepted; the holotype of this variety in Paris (filed incorrectly under the unpublished name *A. krugii* Christ) shows that this variety is the same as *A. sarcodes* Maxon, which I consider to be inseparable from *A. feei* Kunze. However, this list is admittedly a first effort. It will prove useful as a checklist, just as the list of Jamaican ferns by Dr. Proctor is useful even though it too contains numerous nomenclatural and taxonomic errors. There are no new species or varieties described, but there are several new names and combinations proposed: *Cyathea aquilina* var. *maxonii* (Rosenst.) Duek, *Asplenium mortonii* Duek (*Gymnogramma eggersii* Christ, non A. *eggersii* Sodiro), *Thelypteris* subg. *Goniopteris* (Presl) Duek, *T. shaferi* (Maxon & C. Chr.) Duek, *T. reptans* var. *angusta* (C. Chr.) Duek and var. *conformis* (C. Chr.) Duek, *Ctenitis hirta* f. *cubana* (C. Chr.) Duek, *Polystichopsis lurida* var. *sericea* (Mett.) Duek, and *Blechnum exaltatum* (Fée) Duek.—*C.V.M.*

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Volume 63
Number 2
April–June, 1973

QUARTERLY JOURNAL OF THE AMERICAN FERN SOCIETY

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The "American Fern Journal" is an illustrated quarterly devoted to the general study of ferns. It is owned by the American Fern Society, and published at 3200 Falls Cliff Rd., Baltimore, Md. 21211. Second-class postage paid at Baltimore.

Matter for publication and claims for missing numbers (made within six months of the date of issue) should be addressed to the Editor-in-Chief.

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Inadequacies in Herbarium Specimens of Large Ferns

ROBERT G. STOLZE*

During the past several years I have been involved in research on the tree fern genus *Cnemidaria* (Cyatheaceae). Although nearly 2,000 specimens have been available to me for examination, a startling number of these have been partially or totally inadequate for purposes of classification. A small number are of questionable value even for identification. On looking back at the frustrations experienced due to lack of sufficient data (which just as easily could have been provided), it occurred to me that other collectors might benefit by the hindsight I have gained from these problems. I present the following observations, not only for the consideration of inexperienced taxonomists, but for veteran collectors as well, in hopes that they may prompt more effective collecting of large ferns.

Scientists in the field spend large sums of money and exude copious amounts of perspiration collecting in new and exciting areas. Where practicable, a competent field man will always collect sections (at least) of fern rhizomes, in addition to the leaves, knowing that both will yield characters of taxonomic value. Anyone faintly acquainted with the problems of *Thelypteris* would never break off the upper part of the lamina and leave the important basal section behind. And most of us include on our labels information concerning the habit and the habitat of specimens taken. I have seen phanerogam specialists, not especially familiar with problems of fern taxonomy, turn over dozens of leaves in a colony of ferns, attempting to add fertile, as well as sterile, ones to their collecting bags. But what curious forces are at work when I find the unicate of a collection of *Cnemidaria spectabilis,* plus a half dozen duplicates from the holdings of four or five major herbaria, and not one of them contains the petiole or the leaf apex? If the taxonomy of *Cnemidaria* were based on the characters contained on the few central pinnae, the portion of the key containing *C. spectabilis* could be dashed off then and there. Unfortunately, many of the diagnostic characters in *Cnemidaria* are found in the petiole scales, the basal pinnae, and the leaf apex. This applies also to other genera of tree ferns, as witnessed by Tryon's recent classification of the Cyatheaceae (Contr. Gray Herb. **200:** 3–53. 1970), which is strongly based on the characteristics of the scales found on the petiole and crozier. Genera of other huge ferns, such as *Diplazium* and *Ctenitis,* cannot be properly studied merely on the basis of portions of the leaf, because dissection and other characters vary from leaf base to apex.

The collector's problem, then, obviously deals with sheer size of leaf; it is, of course, a very important consideration if the collector is working in a remote rain forest and faces the prospect of packing his specimens out in a dugout canoe or in the baggage compartment of a small airplane. However, to make an effective

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Volume 63, number 1, of the Journal, pp. 1–24, was issued May 9, 1973.

herbarium specimen, one need not rip up an entire *Diplazium* plant, nor trot off with a 12-foot *Cyathea,* trunk and all. Among the *Cnemidaria* specimens which have crossed my work table, a number of excellent collections have turned up which yield all the information needed to form good taxonomic concepts in the genus. With a little thought and planning, anyone in the field can prepare such useful specimens.

On coming upon a lone tree fern at the edge of a patch of rain forest in Costa Rica, one has a natural reluctance to cut down such a magnificent plant. My solution was to cut or break off two or three leaves where the petiole joins the trunk

Fig. 1. *Cyathea multiflora* (*Burger & Stolze 5876,* F) mounted on three sheets showing leaf apex with section of trunk, central portion of rachis with pinnae, and petiole and lower portion of rachis with basal pinnae.

and to take a few croziers from the trunk apex. Each leaf was then cut as follows: (1) a 12- to 14-inch piece of the leaf apex, to fit a herbarium sheet; (2) a 12-inch basal section of the petiole; (3) a piece of the upper petiole, attached to one or two lowermost pairs of pinnae; and (4) a central piece of the rachis with two pairs of pinnae attached (usually the pinnae on one side were trimmed off, leaving only the costa bases to show position of attachment). All could be tied together, tagged, and placed in the collecting bag, then later separated when ready for the plant press. I repeated the procedure with the other leaves taken, depending upon how many duplicate sets were desired. The whole operation required little more time than it takes to read about it, and I usually ended up with three complete sets of leaves, each capable of fitting three herbarium sheets. The end

section of petiole could usually be mounted on the same sheet with the apex, a crozier on another along with the basal pinnae, and the central pinnae on a third sheet. With a set such as this, nearly every feature of the leaf is available for study (see *Fig. 1*). If problems of space and weight were not critical, and especially where a species of tree fern was found in some abundance, I would take along an 8- to 12-inch section of the trunk. Then, as soon as possible, while the material was still relatively fresh, it could be cut into ½-inch cross-sections, which, with some care, could even be mounted on one of the herbarium sheets. A camper's coarse-toothed saw will do the cutting well. I have used the kind which has a blade that can be folded into the handle when not in use. Once a trunk section has thoroughly dried, however, it may take a good fine-toothed power saw to accomplish the task.

It is also important to note in the field book any features that cannot be determined from the specimen: height and diameter of trunk, presence or absence of adventitious roots, whether old leaves are persistent or break away cleanly, total length and shape of mature leaves, etc. It requires only a few moments to record such data, but it thereby completes all the basic morphological information needed to be known about the plant.

Having worked with one of the larger herbaria for a number of years, I have had an opportunity to observe how large a percentage of specimens lack really comprehensive label data. It is also distressing to see how many of the large-leaved genera are represented by just a few pinnae. Research can only be as good as the raw materials available for analysis. Therefore it is incumbent upon the workers in the field, *especially* those in remote areas not likely to be visited frequently, to bring back not just sample data, but specimens complete enough to be fully useful, regardless of the size of the plant.

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Sexual Reproduction in Ophioglossum crotalophoroides[1]

MICHAEL R. MESLER*

In contrast to *Botrychium* and *Helminthostachys*, which reproduce solely by sexual means, the genus *Ophioglossum* is characterized by the formation of clones. Individual plants may give rise to several others by the process of root budding. Sexual reproduction, on the other hand, is considered a relatively rare event. In this paper I wish to discuss a species of *Ophioglossum* which apparently lacks the ability to reproduce asexually and must rely entirely on the formation of gametophytes to produce new individuals.

The Bulbous Adder's-tongue, *Ophioglossum crotalophoroides* Walt., is a plant of disturbed, sandy habitats with a geographical range extending from South Carolina to the Falkland Islands (Clausen, 1938, 1948). The structure and development of the sporophyte of this species easily qualify it as one of the most remarkable, yet little-known, pteridophytes in the world. Its most distinctive feature involves growth of the tuberous rhizomes in an overall downward direction (*Fig. 1*), in contrast to the more usual condition of upward or horizontal growth characteristic of the stems of ferns and other vascular plants. This peculiar phenomenon can readily be observed in the field by examining the under-surfaces of the stems. Light, tan-colored streaks (*Figs. 2, 3*) indicate areas of tissue eruption and emergence. Young tissues, formed by the activity of an apical region that is sunken deep within the stem, push outward and downward as growth proceeds (*Fig. 1*). In contrast to the apparently active stem bases, the upper, older regions are dark in color and partially necrotic. New roots are initiated near the bases of the stems. This type of "upside down" growth strongly contrasts with that of most other species of *Ophioglossum*. Petry (1913) provided the only existing account of the growth and development of the stems of this interesting species.[2]

In March, 1972, I visited several localities in north central Louisiana with R. Dale Thomas and W. H. Wagner, Jr., in search of *O. crotalophoroides*. My primary objective was to collect a series of rhizomes of different ages for use in developmental studies. I was also anxious to discover the previously undescribed gametophytes of this species. It seemed likely that gametophyte characters would compliment those from the sporophyte in elucidating the evolutionary relationships of the species. Furthermore, there is a general need for more information about the gametophytic generation of *Ophioglossum*. Gametophytes are known from a mere seven of the approximately 30 to 40 species in the genus (Boullard, 1963; Mesler, 1972).

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[1] The author acknowledges the generous assistance of R. Dale Thomas, W. H. Wagner, Jr., James G. Bruce, and Louis Martonyi.

[2] Although Petry considered his materials to be mere growth forms ("protocorms") of *O. vulgatum* L., comparison of his descriptions with plants of *O. crotalophoroides* from Louisiana indicates that he was dealing with the latter species.

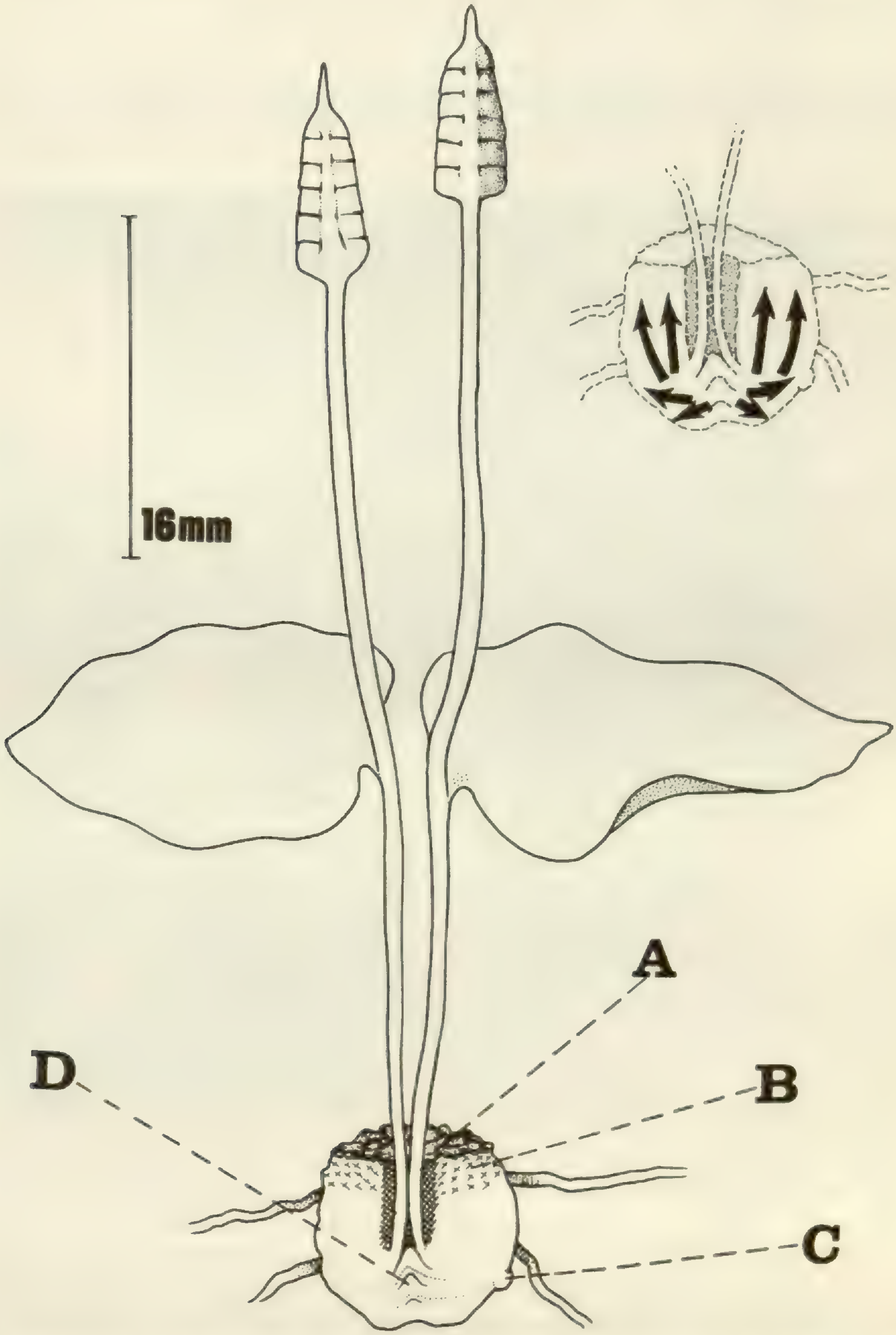
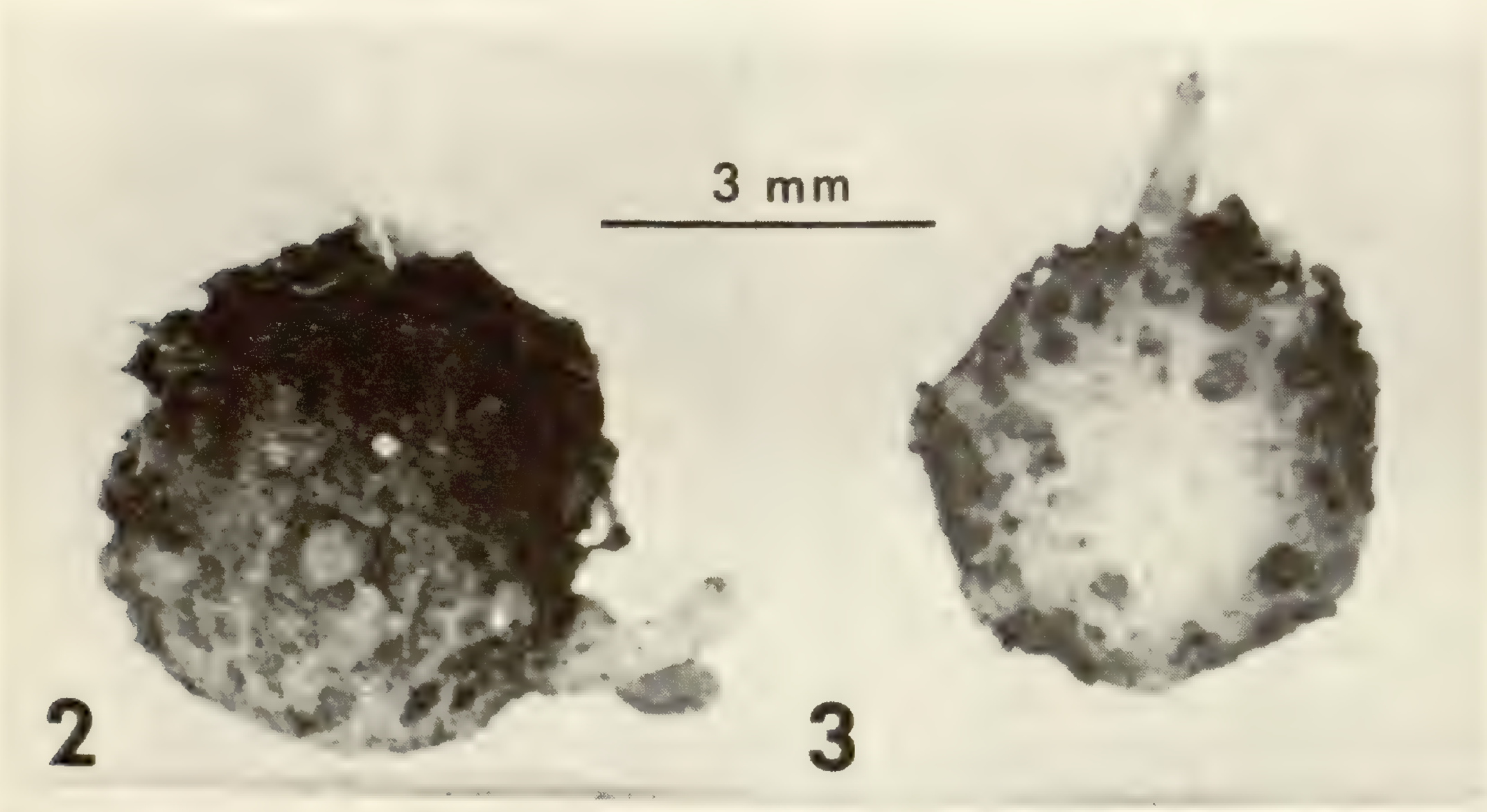


Fig. 1. Diagram of stem development of *Ophioglossum crotalophoroides* as shown in near-median longisection. A = Upper surface with dead, peeling tissues. B = Oldest living tissues. C = Root primordium. D = Leaf primordium. Inset: arrows indicate pathways of cell elongation and differentiation.

We visited the Mount Vernon Baptist cemetery in Ouachita Parish, Louisiana, on March 13, 1972. At this particular locality, small, juvenile leaves were very common, projecting from more-or-less bare spots on the soil. Small leaves are often the hallmark of a site rich in gametophytes in the case of *Botrychium*. In *Ophioglossum,* on the other hand, small leaves most often signal young sporophytes that have arisen by root proliferation rather than from gametophytes. Careful excavation at this site, however, revealed that most of these small leaves arose from tiny, globose stems which, in turn, appeared to be emerging from gametophytes (*Figs. 6, 7*). Because most of the supposed gametophytes were at least partially decayed and all were encrusted with particles of sand, certain determination of their identity was not possible under field conditions.

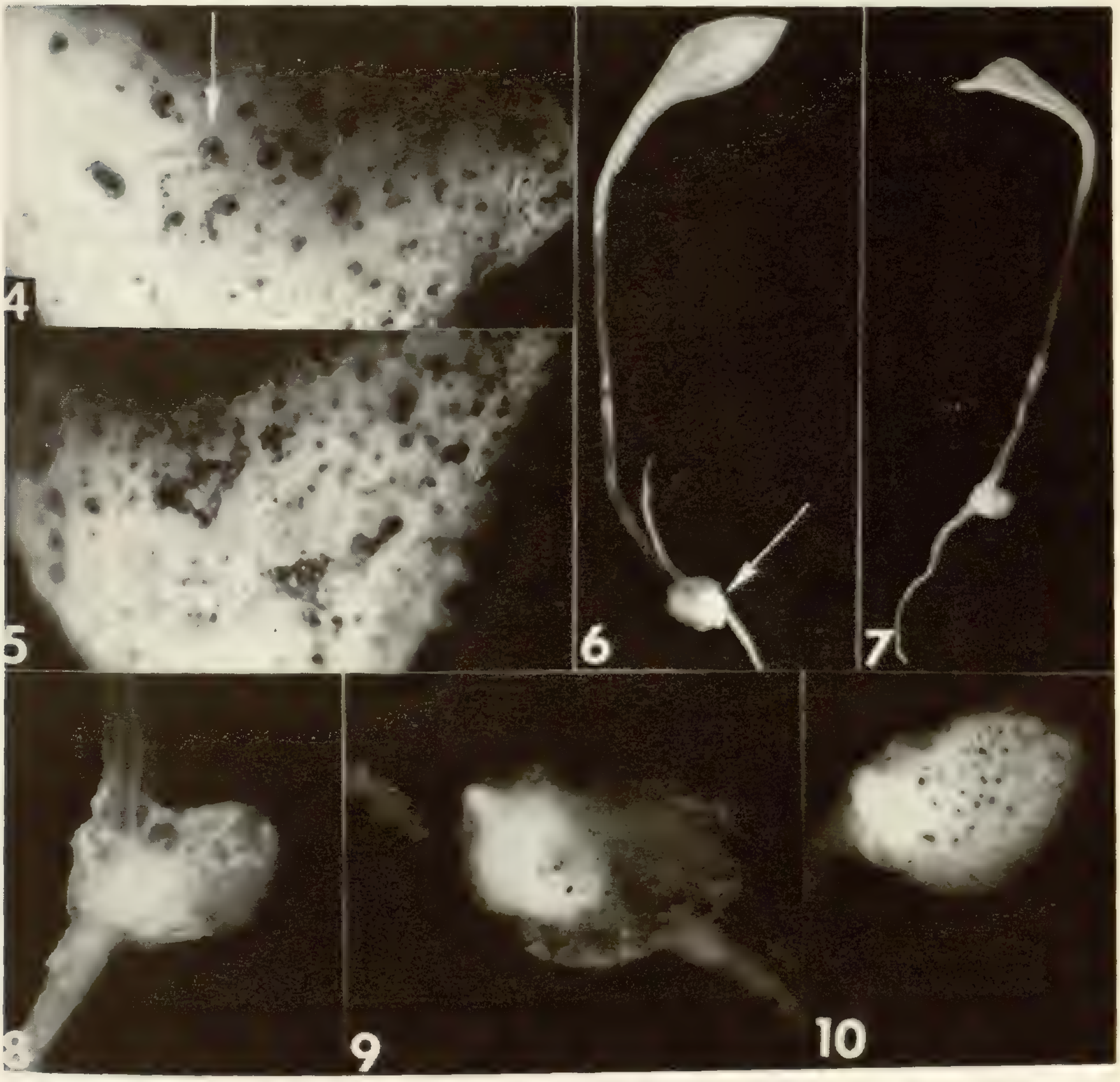


External manifestations of stem growth in *Ophioglossum crotalophoroides*. Fig. 2. Side view. Note cracking of old, outer tissues and emergence of younger tissues near base. Fig. 3. Same stem, bottom view.

Later, in the laboratory, the specimens were cleaned gently with a camel's-hair brush and examined under a dissecting microscope. Their gametophytic nature was clearly indicated by the presence of prominent rhizoid scars and projecting archegonial necks. (*Figs. 4, 5*). Approximately 30 gametophytes were identified in this way, all of them attached to young sporophytes. Due to the fact that most of the gametophytes were relatively old and some partially decayed, a detailed analysis of their anatomy and development was not attempted at this time. The following observations, however, were possible.

The gametophytes of *O. crotalophoroides* are subglobose and often somewhat flattened, ranging in diameter from approximately 1 mm to 3 mm (*Figs. 8–10*). Slender rhizoids are distributed evenly on all surfaces of the prothallus, but arche-

gonia appear to be restricted to the upper surface only. The distribution of antheridia could not be determined accurately. The direction of embryo development appears to be exoscopic, as indicated by the emergence of the stem-leaf sector of the young sporophyte through the upper (archegonial) surface of the gametophyte.



Gametophytes of *Ophioglossum crotalophoroides*. Fig. 4. Projecting archegonial necks (arrow) on upper surface of gametophyte, × 25. Fig. 5. Rhizoid scars (arrow) on lower surface, × 25. Figs. 6, 7. Young sporophytes emerging from gametophytes. Fig. 6. Arrow indicates young, spherical stem, × 2.5. Fig. 7. Same, × 3. Figs. 8–10. Gametophytes with young sporophytes, × 11.

Because the gametophytes of relatively few species of *Ophioglossum* have been investigated, it is difficult to make meaningful comparisons between those of *O. crotalophoroides* and those of other members of the genus. According to Boullard (1963), the gametophytes of most species are cylindrical and upright, with rhizoids

and gametangia distributed over all surfaces. The degree of dorsiventrality suggested by the somewhat flattened, tuberous gametophytes of *O. crotalophoroides,* which bear archegonia only on upper surfaces, is apparently absent in other species of *Ophioglossum.* It seems unlikely, however, that the gametophytes of *O. crotalophoroides* are fundamentally different from others in the genus. As Dr. D. W. Bierhorst has suggested (1972, pers. comm.), the enlarged basal portions of the gametophytes of *O. vulgatum* as figured by Bruchmann (1904) bear some resemblance to the entire gametophyte body of *O. crotalophoroides.* Furthermore, although the gametophytes of *O. crotalophoroides* bear a superficial resemblance to those of *Botrychium,* external manifestations of the distinctive meristematic zones of the latter are lacking. At present, it is prudent to reserve comment on the phylogenetic and taxonomic implications of the structure of the gametophytes of *O. crotalophoroides* until the diversity of prothalli in the genus is better understood.

Currently it appears that all reproduction in *O. crotalophoroides* is sexual. In this respect it differs from all other species of *Ophioglossum* with the possible exception of *O. costatum* R. Brown (discussed by Maheshwari and Singh, 1934, under the name *O. fibrosum* Schum.; see also Welwitsch in Prantl, 1884, p. 308).[3] Although literally thousands of individuals may be present at a given locality (Thomas, 1971), their spatial distribution does not conform to the pattern of crowding and ordering of plants in rows which often accompanies root proliferation in *Ophioglossum.* Furthermore, I could find no structural indications of root budding upon the roots or the stems of this species. In most species of *Ophioglossum,* the process of asexual reproduction by root proliferation can be detected easily by examining the bases of the rhizomes; the large parent roots run directly beneath and perpendicular to their new stems. This relationship is particularly apparent in young rhizomes, but becomes more difficult to observe as rotting occurs in the basal regions of older stems. In the case of *O. crotalophoroides,* however, in which the rhizomes grow in a downward direction with a concomitant obliteration of basal tissues, one would not expect to see signs of the parent root except in very young stems. I examined stems of all ages from several localities in Louisiana and found no evidence of reproduction by root budding. Futhermore, de Lichtenstein (1944) noted the absence of asexual reproduction in plants of the same species from South America. This species, therefore, appears to be totally dependent on the formation of gametophytes for reproduction.

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[3] *Ophioglossum costatum* R. Brown resembles *O. crotalophoroides* in several other respects. Its rhizomes are tuberous with a deeply situated apex (Mahabale, 1962) and a reticulate vascular system comparable to that of *O. crotalophoroides.* Although the overall dynamics of stem growth are not well known, the figure in Maheshwari and Singh (1934, fig. 45) suggests that the stems develop in a manner similar to those of *O. crotalophoroides.* Leaf venation is more complex than that of *O. crotalophoroides* but resembles *O. opacum,* a species considered very similar to *O. crotalophoroides* in other respects (Clausen, 1938, 1948; de Lichtenstein 1944). It seems probable that *O. costatum* is taxonomically more closely related to *O. crotalophoroides* than previously thought.

LITERATURE CITED

BOULLARD, B. 1963. Le gamétophyte des Ophioglossacées. Considérations biologiques. Bull. Soc. Linn. Normandie **4:** 81–97.

BRUCHMANN, H. 1904. Ueber das Prothallium und die Keimpflanze von Ophioglossum vulgatum L. Bot. Zeit. **62:** 227–247.

CLAUSEN, R. T. 1938. A monograph of the Ophioglossaceae. Mem. Torrey Bot. Club **19:** 1–177.

————. 1948. The Ophioglossum of the Falkland Islands and the relationships of Ophioglossum crotalophoroides. Amer. Fern J. **38:** 176–186.

LICHTENSTEIN, JUANA S. de. 1944. Las Ofioglosáceas de la Argentina, Chile y Uruguay. Darwiniana **6:** 380–441.

MAHABALE, T. S. 1962. Species of Ophioglossum in India: their taxonomy and phylogeny. Bull. Bot. Surv. India **4:** 71–84.

MAHESHWARI, P. and B. SINGH. 1934. The morphology of Ophioglossum fibrosum. J. Ind. Bot. Soc. **13:** 103–123.

MESLER, M. R. 1972. The gametophyte of Ophioglossum palmatum L. (Abstr.) Amer. J. Bot. **59:** 679.

PETRY, L. C. 1913. A protocorm of Ophioglossum. Bot. Gaz. **55:** 155–166.

PRANTL, K. 1884. Beiträge zur Systematik der Ophioglosseen. Jahrb. K. Bot. Gart. Berlin **3:** 297–350.

THOMAS, R. D. 1971. Bulbous adder's-tongue common in Louisiana. Amer. Fern J. **71:** 39–41.

"AN ILLUSTRATED GUIDE TO THE FERNS AND FERN ALLIES OF SHENANDOAH NATIONAL PARK, VIRGINIA," by P. M. Mazzeo. Bull. Shenandoah Nat. Hist. Assoc. 6: 1–52. illustr. 1972. $1.00—Peter Mazzeo, who has been an energetic student and collector of the flora of Virginia for many years, has brought together the knowledge of the pteridophytes of Shenandoah National Park, which is one of the most heavily used national parks in the nation. Being largely mountainous and relatively dry with few bogs or swamps, the Park does not have a large pteridophyte flora; only 47 taxa are known. Mr. Mazzeo has prepared keys which are readily useable by the botanically uninitiated, brief descriptions, and valuable field notes for each taxon. The New York Botanical Garden very kindly permitted reprinting of some of the illustrations from "The New Britton and Brown Illustrated Flora" (1952), which adds greatly to the usefulness and beauty of the booklet. The book does contain a number of typographical errors. The scales given for figs. 8, 9, 11, 17, 21, 23, and the plants in fig. 29 should be multiplied by ½ (i.e., reduced from ×½ to ×¼); figs. 2, 10, and 27 should be multiplied by ⅔ (i.e., reduced from ×½ to ×⅓); and the pinnules in fig. 29 are both natural size (×1). A glossary (with some regrettably ambiguous entries), a list of the meanings of scientific names, and an index conclude the work. The booklet may be purchased in the visitor centers in the Park or directly from Mr. Mazzeo, U. S. National Arboretum, Washington, DC 20002.—*D.B.L.*

Observations of the Hypodermises of Ferns[1]

WILLARD W. PAYNE and KATHLEEN M. PETERSON*

While engaged in routine screening of fern leaves in connection with stomatal studies presently under way, we have been struck by the occurrence, nature, and variability of the hypodermal layers encountered. Examination of the likely literature sources has disclosed no detailed account of these tissues, although it is probable that their occurrence can be of significant taxonomic value for groups in which they are found. It is the purpose of this report to summarize our observations in expectation that they may be of more general interest.

MATERIALS AND METHODS

For examination of whole leaf segments, blade fragments were cleared in hot, 5% NaOH, following the quick (four minute) method of Payne (1969), and were stained in chlorazol black E in 95% ethanol, aqueous safranin, or ferric chloride-tannic acid, following standard histological procedures (Johansen, 1940). Materials were prepared for sectioning by refreshing dried leaf pieces in detergent solution or fixing fresh material in FAA, and embedding in "Paraplast" (m.p. 56-67°C; manufactured by Sherwood Medical Industries, Inc., St. Louis, Mo.) after dehydration through a standard TBA-paraffin oil series. Because brittleness of the tissues prepared from herbarium specimens presented microtomy problems, difficulties magnified by the frequent occurrence of raphide and other idioblasts, it was necessary to soak the paraffin blocks in water from one to four days (or longer) after exposing tissues on the proximal faces. Sections 7–10μ thick were stained in "Johansen's quadruple stain" (safranin, fast green, methyl violet, orange-G), as described by Johansen (1940, p. 88). Camera lucida drawings of various epidermal layers are shown in *Figs. 1–15*, and photographs of sectioned and cleared material of special interest are presented in *Figs. 17–25*.

OBSERVATIONS AND DISCUSSION

Linsbauer (1930) credits the term "hypoderm" to Kraus (1865–66), who used it in a paper dealing with the cycadophyte epidermis and defined it as a layer of cells distinct from the epidermis from the time of its initiation. DeBary (1884), in a general work dealing with phanerogams and ferns, discusses the hypodermis only in relation to the stem, and defines it simply as a layer of tissue immediately beneath the epidermis that is typically more or less differentiated from the amorphous parenchyma deeper within. Metcalfe and Chalk (1950) point out that the hypodermis is properly a specialized layer underlying the epidermis, and state (p. XVI): "A horizontally divided epidermis is not always easy to distinguish from a hypoderm, because the only difference between the two is that a true hypoderm is derived from the mesophyll in the course of development, whereas the divided

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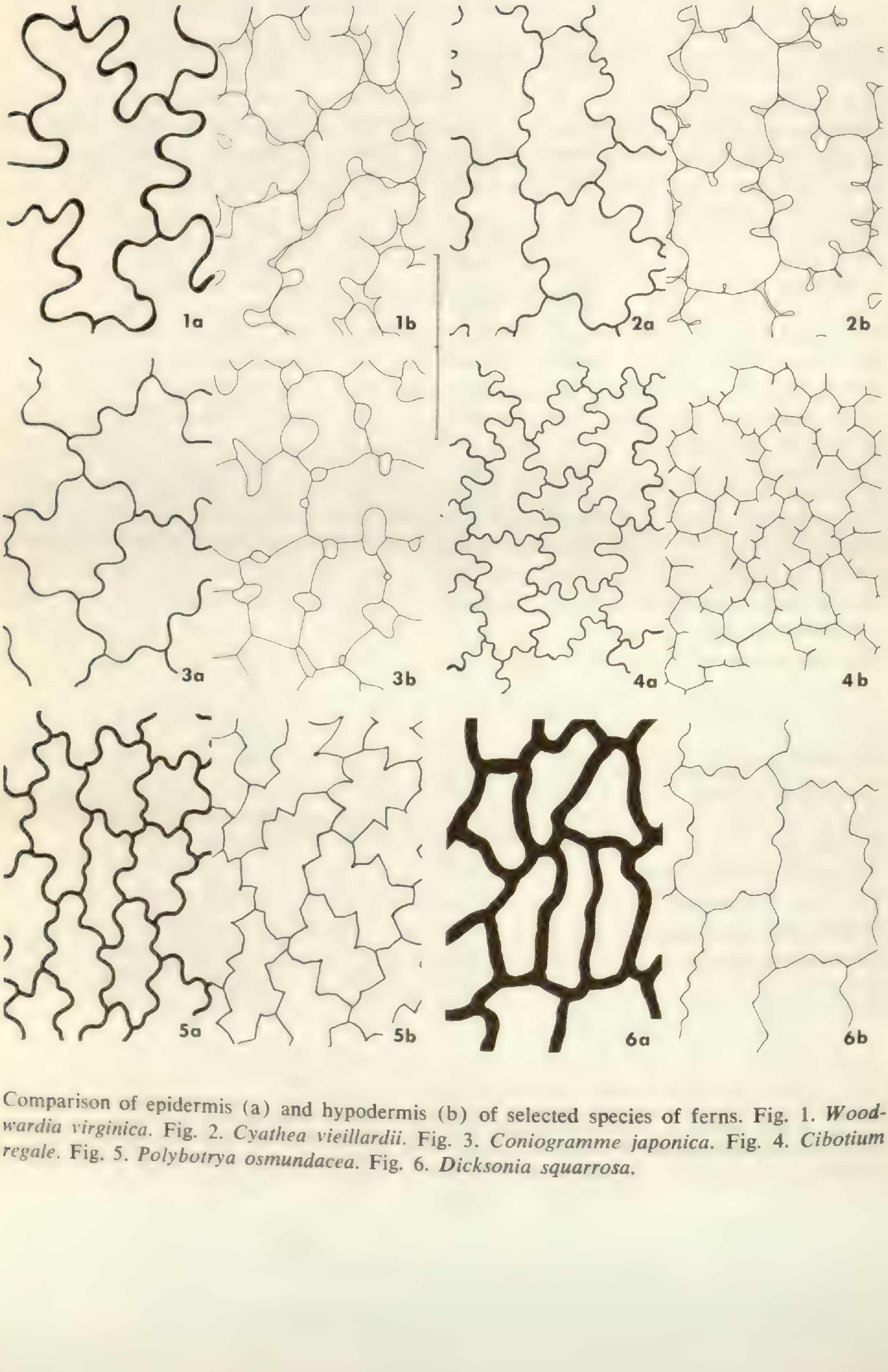
[1] This work was supported in part by National Science Foundation grant GB-30477 to Payne. We are grateful to Mrs. Toshiko Une Nakamura for valuable technical assistance.

TABLE 1. CHARACTERISTICS OF HYPODERMAL LAYERS IN FERNS.

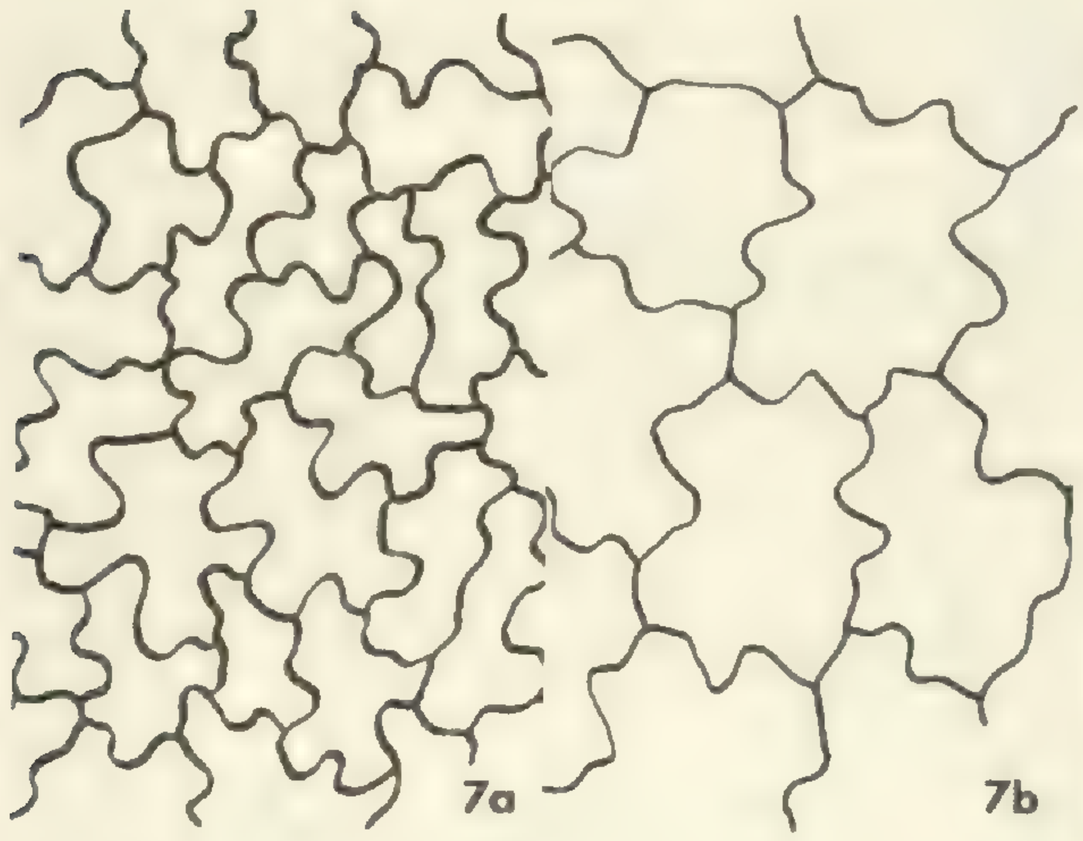
Species	*Wall Thickness**	*Cell Size**	*Resembling mesophyll*	*Position*	*Multiple layers*	*Layers unlike*
MARATTIACEAE						
Angiopteris evecta	Same	Same	No	Adaxial	No	
Marattia attenuata	Thin	Larger	No	Adaxial	No	
CYATHEACEAE						
Alsophila aspera	Thin	Same	Yes	Adaxial	No	
Cyathea straminea	Thin	Same	Yes	Adaxial	No	
C. vieillardii	Thin	Same	Yes	Adaxial	No	
DICKSONIACEAE						
Cibotium barometz	Thin	Same	Yes	Adaxial	No	
C. chamissoi	Thin	Larger	Yes†	AB+AD†	Yes	Yes
C. menziesii	Thin	Larger	No	Adaxial	Sometimes	Yes
C. regale	Thin	Same	Yes	Adaxial	No	
C. schiedei	Thin	Same	Yes	Adaxial	No	
Culcita coniifolia	Thin	Same	Yes	Adaxial	No	
C. macrocarpa	Thin	Same	Yes	Adaxial	No	
Dicksonia squarrosa	Thin	Same	No	Adaxial	No	
DAVALLIACEAE						
Davallia fejeensis	Thin	Same	Yes	Adaxial	No	
D. ornata	Thick	Larger	No	AB+AD	Sometimes	No
D. pentaphylla	Thick	Larger	No	AB+AD	Yes	Yes
Oleandra colubrina	Thin	Same	Yes	Adaxial	Sometimes	Yes
CHEILANTHACEAE						
Coniogramme japonica	Thin	Same	Yes	Adaxial	No	
PTERIDACEAE						
Pteridium aquilinum	Thin	Same	Yes	Adaxial	No	
BLECHNACEAE						
Blechnum serrulatum	Same	Larger	No	Adaxial	No	
Sadleria sp.	Same	Same	No	AB+AD	Yes	No
Woodwardia virginica	Thin	Smaller	Yes	Adaxial	No	
ATHYRIACEAE						
Diplazium costale	Thin	Same	Yes	Adaxial	No	
D. wilsonii	Thin	Same	Yes	Adaxial	No	
DRYOPTERIDACEAE						
Polybotrya osmundacea	Thin	Same	Yes	Adaxial	No	
ACROSTICHACEAE						
Acrostichum aureum	Thick	Larger	No	AB+AD†	Yes	Yes
A. danaeifolium	Thick	Larger	No	Adaxial	Yes†	Yes
Hymenodium crinitum	Thin	Larger	No	Adaxial	Sometimes	Yes
VITTARIACEAE						
Vittaria lineata	Thin	Same	Yes	Adaxial	No	
POLYPODIACEAE						
Drynaria quercifolia	Thin	Same	Yes	Adaxial	No	
Photinopteris speciosa	Thick	Larger	No	AB+AD	Yes	Yes
Pyrrosia lanceolata	Same	Larger	Yes	Adaxial	Yes	Yes
Pyrrosia sp.	Thick	Larger	No	Adaxial	Yes	No
SALVINIACEAE						
Salvinia natans			Aberrant			

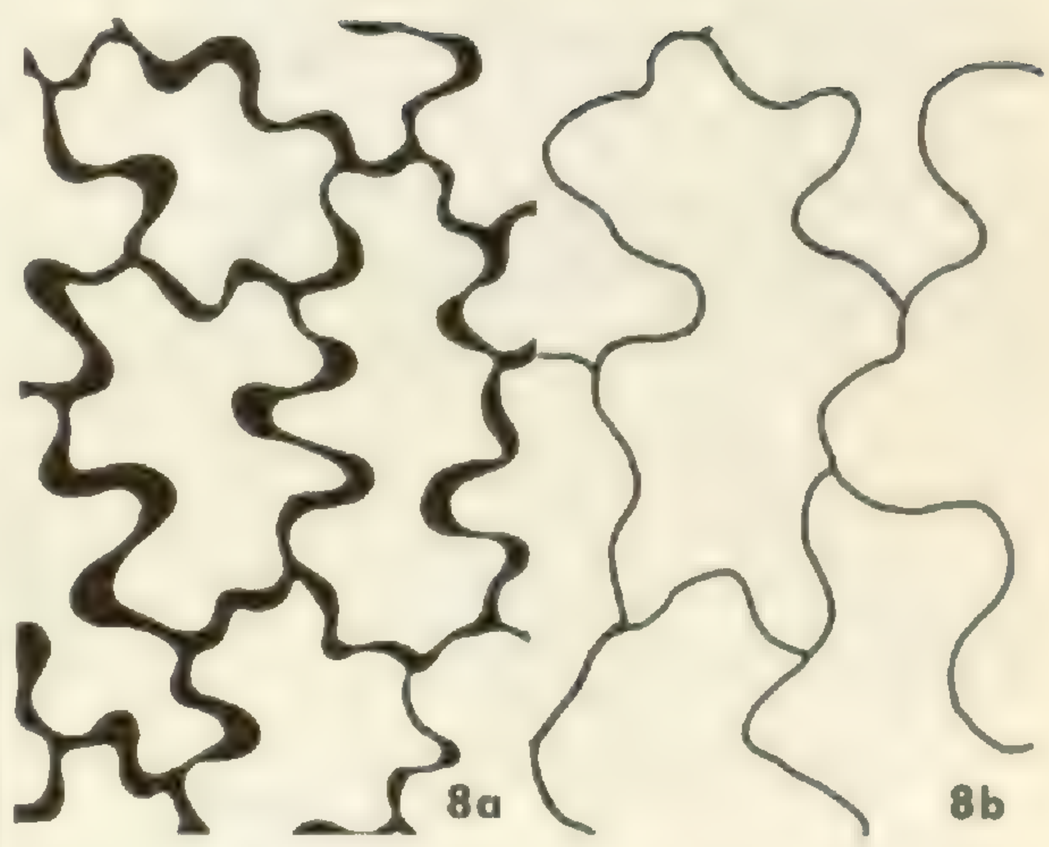
* In comparison with cells of adjacent epidermis.

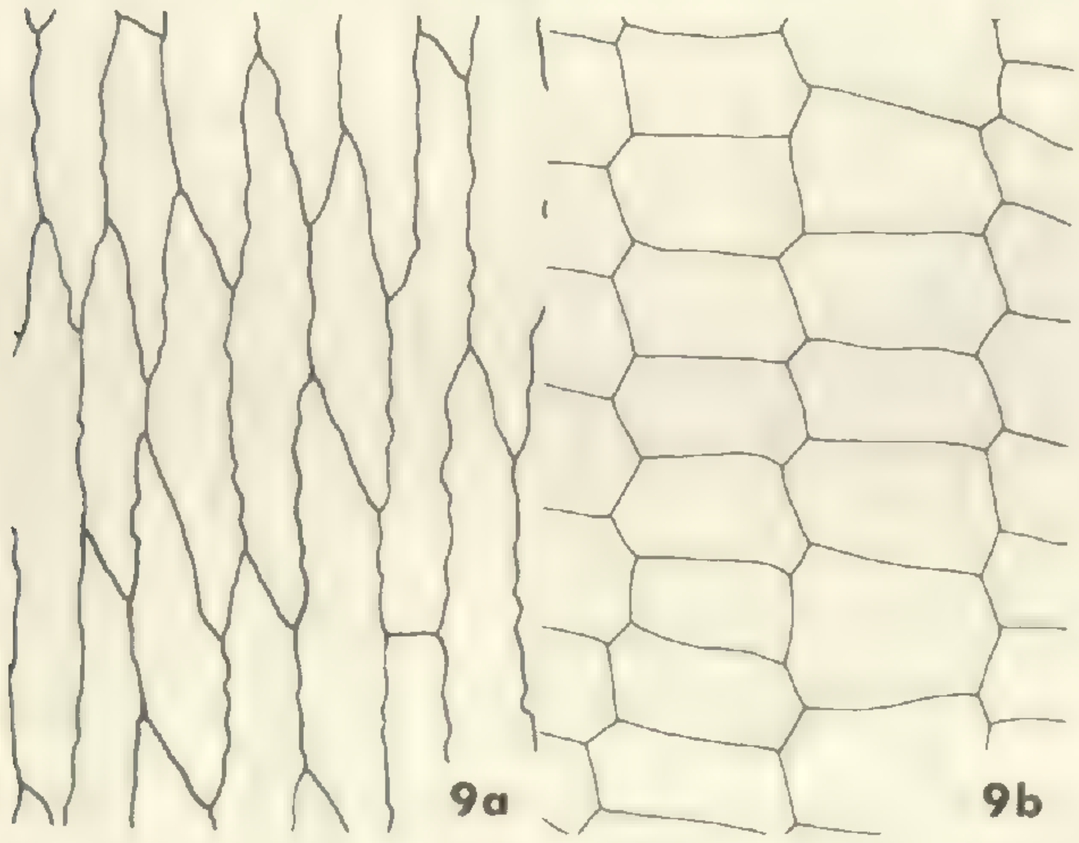
† Intergrading with adjacent mesophyll, or of sporadic occurrence.

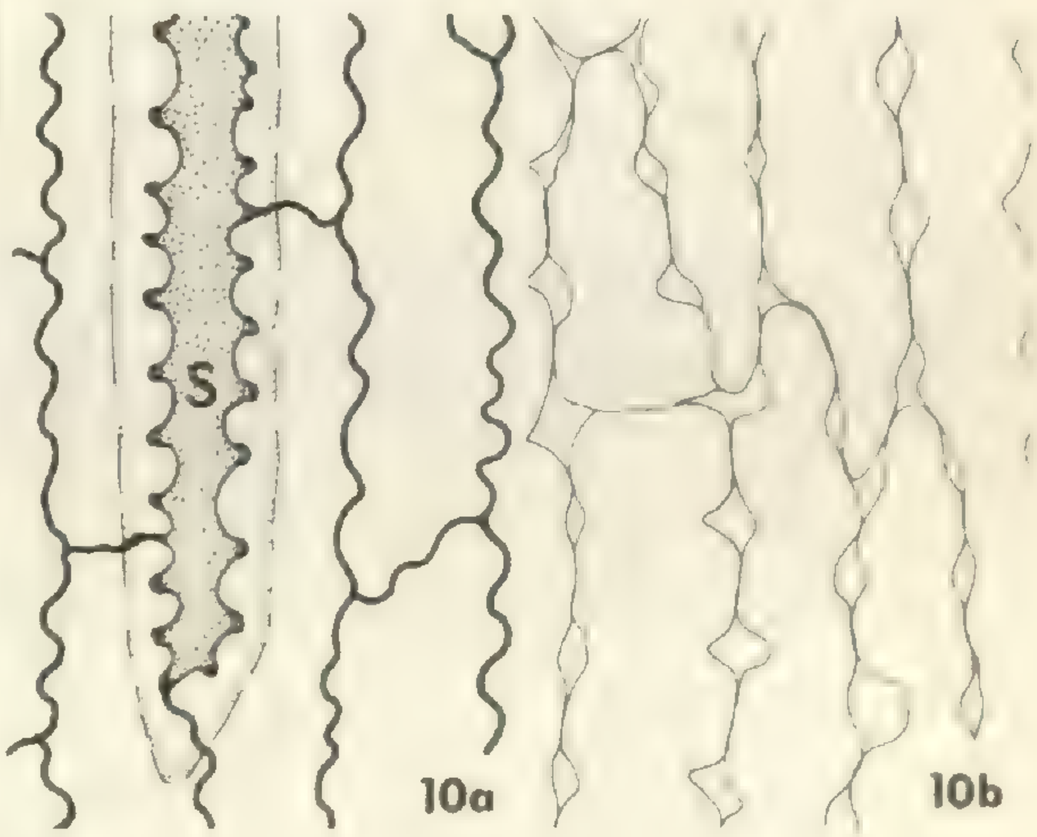


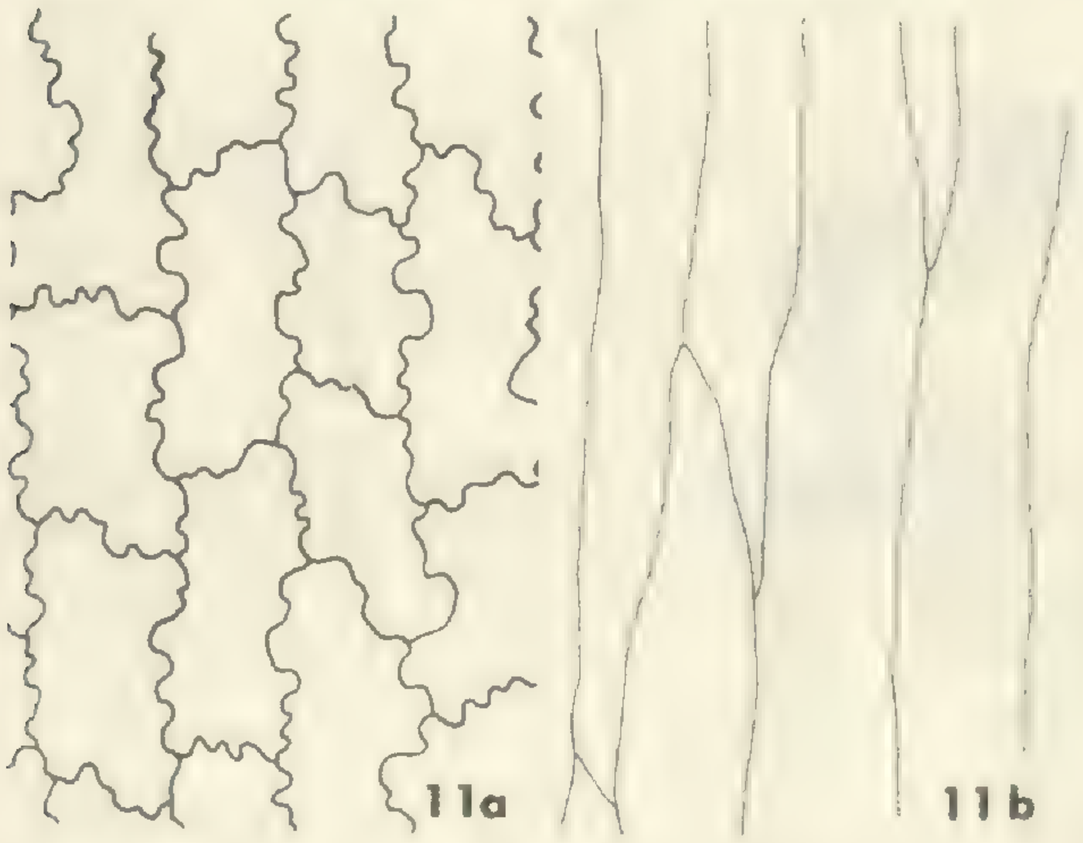
Comparison of epidermis (a) and hypodermis (b) of selected species of ferns. Fig. 1. *Woodwardia virginica*. Fig. 2. *Cyathea vieillardii*. Fig. 3. *Coniogramme japonica*. Fig. 4. *Cibotium regale*. Fig. 5. *Polybotrya osmundacea*. Fig. 6. *Dicksonia squarrosa*.

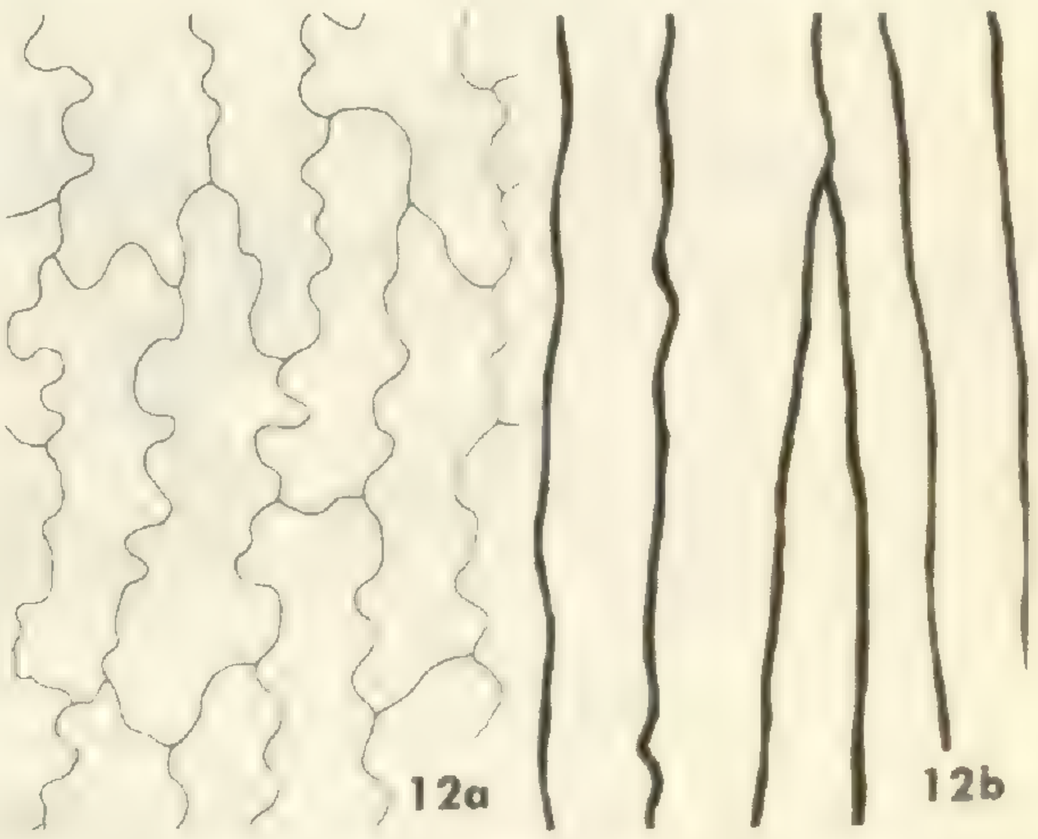




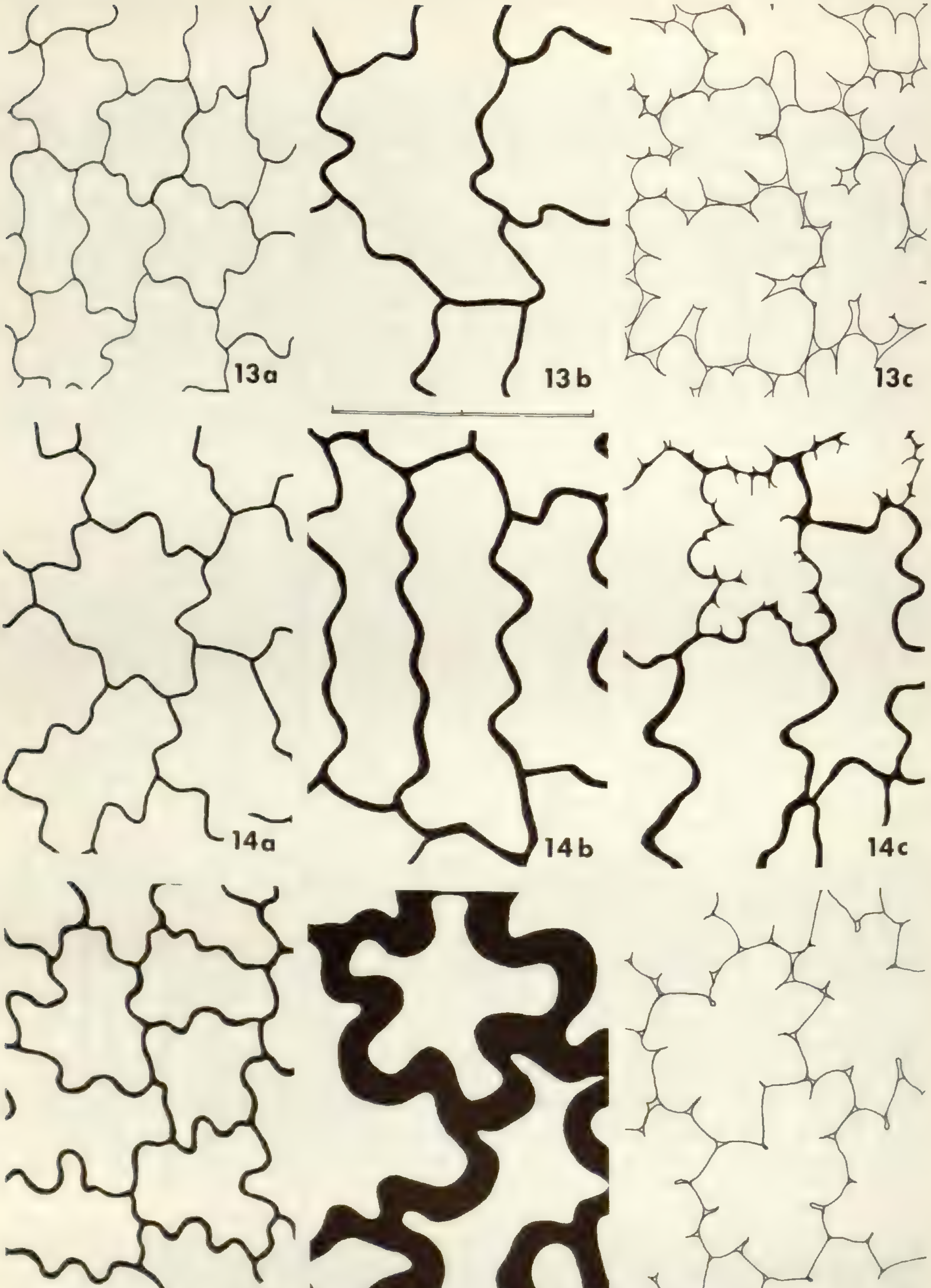








Comparison of epidermis (a) and hypodermis (b) of selected species of ferns. Fig. 7. *Cibotium menziesii*. Fig. 8. *Sadleria* sp. Fig. 9. *Marattia attenuata*. Fig. 10. *Vittaria lineata*; s = sclereid idioblast of the epidermis. Fig. 11. *Davallia pentaphylla*. Fig. 12. *Davallia ornata*.



Comparison of epidermis (a), outermost (b), and inner (c) hypodermal layers of selected ferns. Fig. 13. *Acrostichum danaeifolium*. Fig. 14. *Acrostichum aureum*. Fig. 15. *Photinopteris speciosa*.

epidermis, as its name implies, arises by partition of the epidermal cells themselves." They point out that one would expect the cells of the underlayers of a multiple epidermis to be aligned and structured so as to reflect the ontogenetic relationship with the outermost layer, whereas this would not be so for the hypodermis which is derived from a mesophyllous progenitor. Esau (1953) also emphasizes the problem of distinguishing the lower layers of a multiple epidermis from a true hypodermis, and says that certainty can be attained only with developmental data.

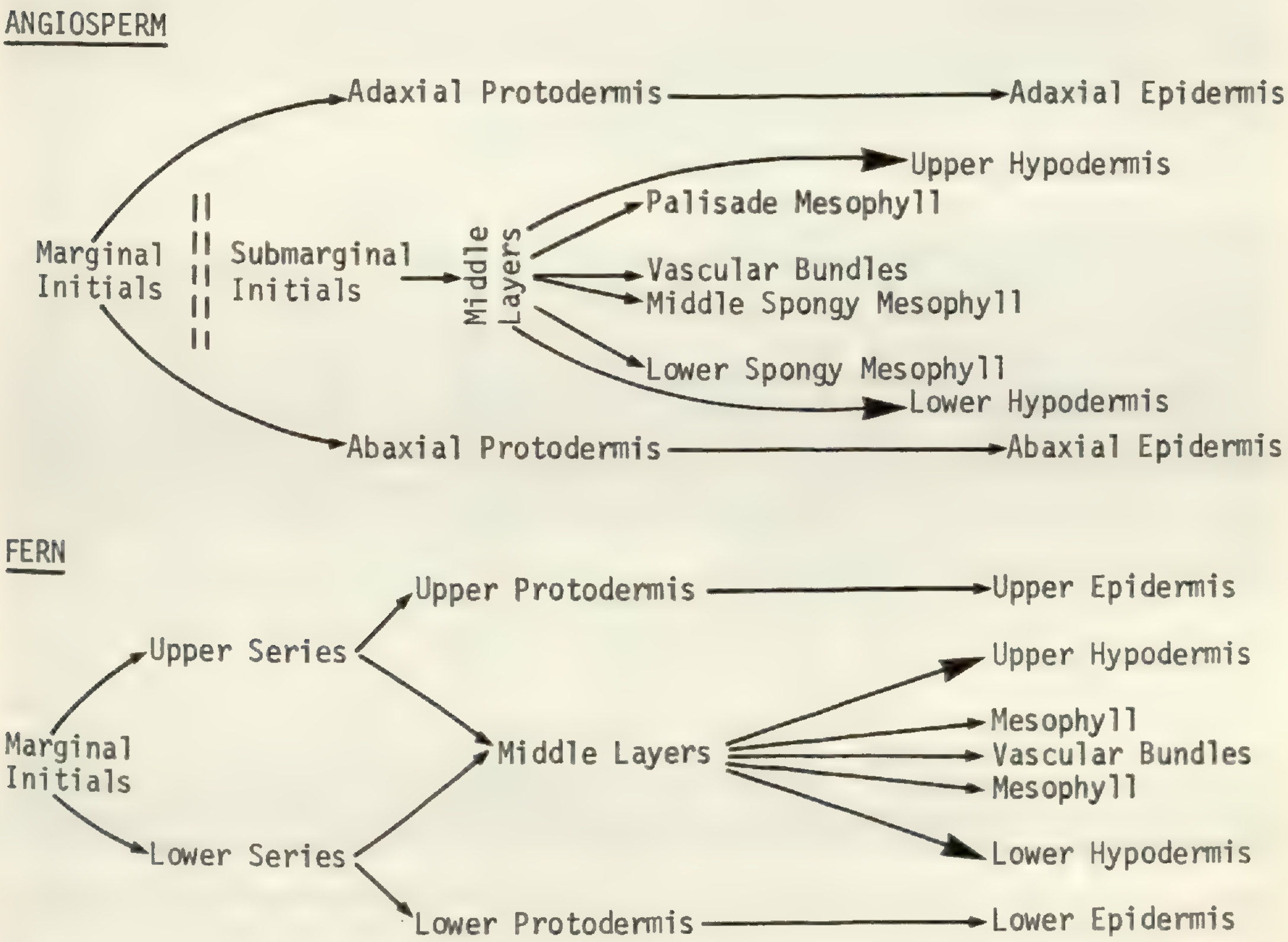
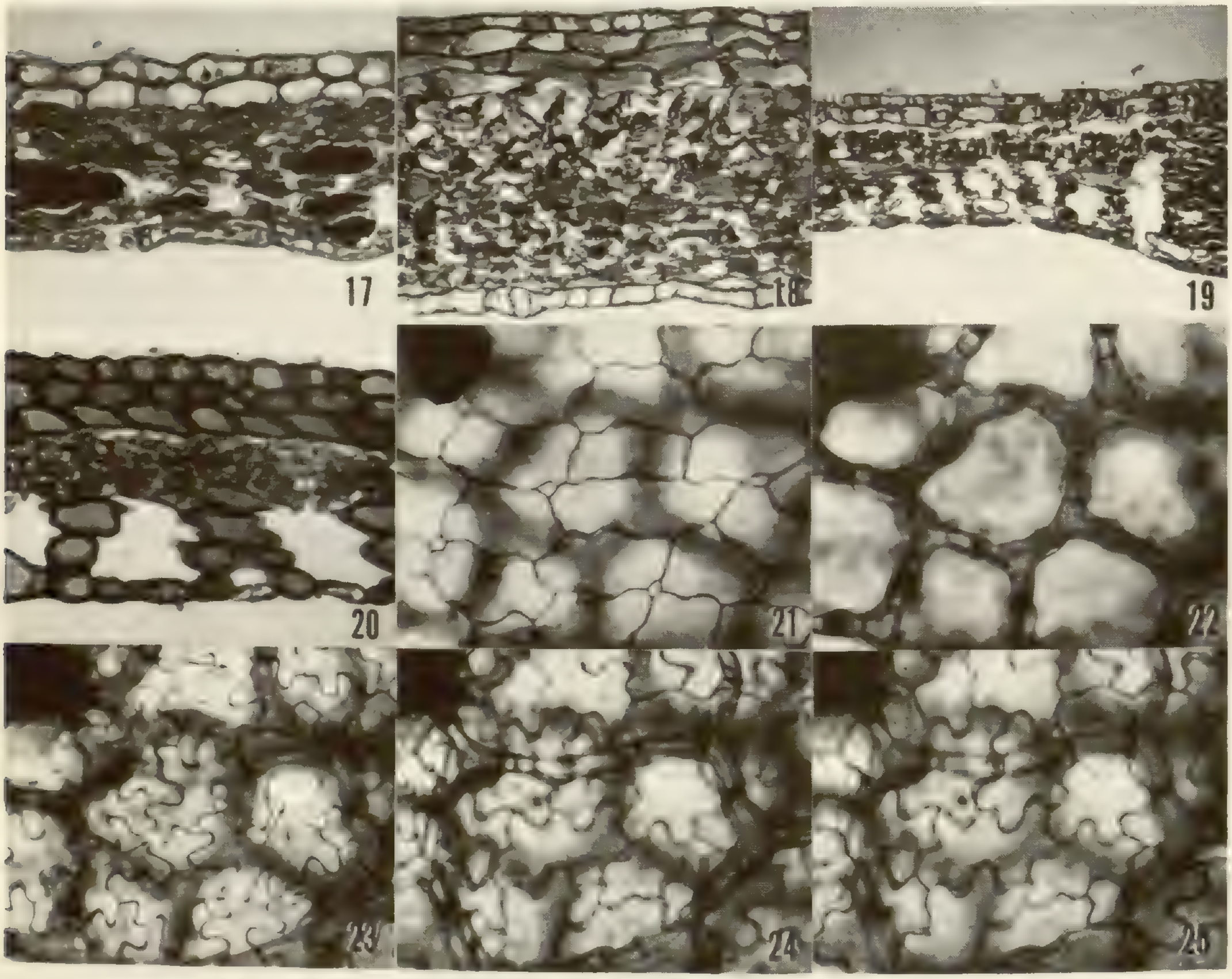


Fig. 16. Comparison of genesis of leaf tissues in angiosperms and ferns. Upper diagram developed from those of Foster (1936); lower after illustrations from Bower (1923).

Ontogenetically, this distinction would seem to be more clear among flowering plants than among ferns. Foster (1936) has suggested that the lamina of the angiospermous leaf is produced through the action of two sets of initial cells, the "marginal initials" which produce the upper and lower epidermises, and the "submarginal initials" which produce the layers between. In contrast, Bower (1923) has shown that the marginal initials of fern laminas produce an upper and lower series, each of which gives rise to one of the epidermises and its subjacent layers. These distinctions are presented diagrammatically in *Fig. 16*, the diagrams being extrapolations from those of Foster (1936) and the drawings of Bower (1923, p. 110).

For the species examined here, there has been no observation suggesting a multiple epidermis, as strictly defined. All hypodermal layers consist of cells with clearly individualistic features of size and placement, suggesting development that is ontogenetically independent from that of the epidermis.



Internal structure of the leaves of selected ferns. Fig. 17. *Marattia attenuata,* with a single, adaxial hypodermal layer. Fig. 18. *Pyrrosia lanceolata* with a three-layered, adaxial hypodermis. Fig. 19. *Acrostichum aureum,* with both adaxial and abaxial hypodermises. Fig. 20. *Davallia pentaphylla,* with the entire spongy mesophyll layer converted to hypodermis. Figs. 17–20 ca × 70. Figs. 21–25. *Salvinia natans;* series of optical sections from the same portion of a single frond, ca × 172. Fig. 21. Upper epidermis with deeply sunken, obscure stomata. Fig. 22. Upper aerenchymatous mesophyll with relatively small air spaces. Fig. 23. "Mesodermis" with well defined intercellular spaces (arrows). Fig. 24. Lower aerenchymatous mesophyll with relatively large air spaces. Fig. 25. Lower epidermis.

Hypodermal differences of interest include the following: (1) presence or absence, (2) position with regard to abaxial and adaxial surfaces, (3) number of hypodermal layers, (4) structure of the hypodermis as compared to that of the epidermis, and (5) structure of the hypodermis itself.

The occurrence of hypodermal layers among the specimens sampled is shown in *Table 1*. Other taxa sampled from the same and different families but which lacked

hypodermal layers are the following; families marked with an asterisk include other members having hypodermises:

OPHIOGLOSSACEAE—*Botrychium dissectum, B. lunaria, B. virginianum, Ophioglossum vulgatum;* MARATTIACEAE*—*Marattia douglasii;* OSMUNDACEAE—*Osmunda cinnamomea, O. claytoniana, O. regalis, Todea barbara;* GLEICHENIACEAE—*Dicranopteris linearis, Gleichenia longissima, Stromatopteris moniliformis.* SCHIZAEACEAE—*Anemia adiantifolia, A. hirsuta, A. oblongifolia, A. phyllitidis, A. villosa, Lygodium circinnatum, L. japonicum, L. palmatum, Schizaea dichotoma;* CYATHEACEAE*—*Alsophila corcovadensis, Sphaeropteris australis;* HYMENOPHYLLACEAE—*Trichomanes curtii, T. ekmanii, T. godmanii, T. kraussii, T. membranaceum, T. punctatum, Vandenboschia* sp.; DENNSTAEDTIACEAE—*Dennstaedtia punctilobula;* CHEILANTHACEAE*—*Adiantopsis radiata, Anogramma leptophylla, Anopteris hexagona, Bommeria hispida, Cheilanthes alabamensis, C. gracillima, Cryptogramma acrostichoides, Llavea cordifolia, Pellaea glabella;* PTERIDACEAE*—*Pteridium caudatum, P. latiusculum;* LINDSAEACEAE—*Lindsaea alutacea, Odontosoria aculeata Sphenomeris chinensis, Tapeinidium moorei.* ADIANTACEAE—*Adiantum dolosum, A. lucidulum*; BLECHNACEAE*—*Blechnum spicant, Doodia media.* ONOCLEACEAE—*Matteuccia struthiopteris; Onoclea sensibilis, O. sensibilis* var. *obtusilobata;* ASPLENIACEAE—*Asplenium adiantum-nigrum, A. bradleyi, A. bulbiferum, A. jamaicense, A. monanthes, A. pinnatifidum, Camptosorus rhizophyllus, Diellia falcata, Phyllitis scolopendrium, Schaffneria nigripes;* ATHYRIACEAE*—*Athyrium angustum, A. pycnocarpon, Cystopteris bulbifera, Diplazium centripetale.* DRYOPTERIDACEAE*—*Arthrobotrya* sp., *Ctenitis squamifera, Didymochlaena lunulata, Dryopteris cristata, D. goldiana, Fadyenia hookeri, Gymnocarpium dryopteris, Thelypteris hexagonoptera;* ACROSTICHACEAE*—*Elaphoglossum elongatum, Peltapteris peltata;* NEPHROLEPIDACEAE—*Nephrolepis biserrata, N. elegantissima;* VITTARIACEAE*—*Antrophyum reticulatum;* POLYPODIACEAE*—*Dipteris conjugata, Polypodium aureum, P. hymenophylloides, P. lanceolatum, P. phyllitidis, P. polypodioides, P. virginianum;* MARSILEACEAE—*Marsilea macropoda, M. quadrifolia, M. vestita, Pilularia globulifera, Regnellidum diphyllum;* SALVINIACEAE (Anomalous)—*Azolla filiculoides, A. mexicana;* WOODSIACEAE—*Diacalpe aspidioides, Peranema cyatheoides, Woodsia glabella, W. obtusa.*

From these tabulations, it may be seen that hypodermises are scattered throughout the Pteridophyta, and they occur among groups of all supposed levels of advancement. They were found among 13 of the 28 families sampled (ca 46%), and they occurred in 34 of the 126 species examined (ca 26%). Samples from five genera (*Marattia, Alsophila, Pteridium, Blechnum,* and *Diplazium*) included species both with and without hypodermises. Although these surveys are not exhaustive, they are sufficiently extensive to suggest validity of the observations that the presence of hypodermal layers is variable within the division, within generic complexes, and within genera.

Most often a hypodermis is found in association with only the upper (adaxial) epidermis of the frond (*Table 1; Figs. 17, 18*). However, seven of the 34 species with hypodermises had them associated with both the adaxial and abaxial surfaces (*Table 1; Figs. 19, 20*), and in some instances (e.g., specimens of *Sadleria* and *Davallia;* latter *Fig. 20*) the entire spongy mesophyll layer seems to be modified as a hypodermal system. No species was observed to have only an abaxial hypodermis.

Perhaps the most unusual situation encountered in this study was that for *Salvinia natans* (*Figs. 21-25*). This species has two well-developed systems of meso-

phyll air chambers, one with smaller chambers adjacent to the upper epidermis (*Figs. 21, 22*), and one with larger chambers adjacent to the lower (*Figs. 24, 25*). These are separated by a clearly defined layer of flattened, squamous cells, resembling a typical epidermal layer in general appearance but provided with scattered intercellular spaces that do not seem random in placement (*Fig. 23*). The only term appropriate for this layer would be "mesodermis."

The majority of species examined have hypodermal layers only one cell thick (*Figs. 1–12, 17, 19*), but approximately one-third (11/34) have two or more well-defined layers (*Figs. 13–15, 18, 20*). In most of the species with only a single hypodermal layer, either the epidermis and hypodermis are similar in cell wall thickness and cell size, or the hypodermis consists of somewhat larger cells with somewhat thinner walls (*Figs. 1–11*). However, in many of the species with two or more hypodermal layers, the outermost is comprised of thick-walled cells, and gives the impression of being responsible for most of the dermal functions of support and protection (*Figs. 13–15*). In the majority of species with two hypodermal layers (9/11), they are clearly different from one another in attributes of cell size, orientation, shape, or wall thickness (*Figs. 13–15*).

The hypodermis is very variable with regard to its definition as a discrete, dermatoid layer. In many ferns (*Figs. 5–9, 11–15*), it (or its outermost layer) is highly differentiated from the mesophyll and strongly resembles the epidermis in morphology and staining properties (see *Figs. 17–20*). However, such forms intergrade with forms in which the hypodermal cells are rather loosely organized (*Figs. 1b, 2b, 13c*) and quite "mesophyllous" in appearance, or that are highly differentiated but still provided with intercellular spaces (*Figs. 3b, 4b, 15c*).

All of the attributes discussed briefly here are of potential value for studies of fern taxa, and may be useful for assessment of relative specialization and of relationships. Although all aspects need to be examined and tested further, we suggest that the occurrence of the hypodermis is, itself, a specialization in any evolutionary line. Those hypodermises which are most mesophyllous would seem to be least specialized, whereas those that are most dermatoid, or that have unusual attributes of cell wall thickening or cell arrangement, appear to be most advanced. Other questions that require additional study include those of specific constancy and variability, function, and selective advantage.

LITERATURE CITED

BOWER, F. O. 1923. The ferns, Vol. 1. University Press, Cambridge.

De BARY, H. A. 1884. Comparative anatomy of the vegetative organs of the phanerogams and ferns. Translated by F. O. Bower and D. H. Scott. Clarendon Press, Oxford.

ESAU, K. 1953. Plant anatomy. John Wiley and Sons, New York.

FOSTER, A. S. 1936. Leaf differentiation in angiosperms. Bot. Rev. **24:** 304–316.

JOHANSEN, D. A. 1940. Plant microtechnique. McGraw Hill, New York.

KRAUS, G. 1865–66. Ueber den Bau der Cycadeenfiedern. Jahrb. Wiss. Bot. **4:** 305–348.

LINSBAUER, K. 1930. Die Epidermis. Gebrüder Borntrager, Berlin.

METCALFE, C. R., and L. CHALK. 1950. Anatomy of the Dicotyledons, Vol. 1. Clarendon Press, Oxford.

PAYNE, W. W. 1969. A quick method for clearing leaves. Ward's Bull. **8**(61): 4–5.

Facultative Apomixis and Polyploidy in Matteuccia orientalis

ROBERT M. LLOYD*

Life-cycles in leptosporangiate homosporous ferns which normally occur in nature have been reported to be either obligately sexual, with a haploid–diploid alternation of generations, or obligately apogamous. Apogamous reproduction is a process which requires two basic phenomena: production of viable spores either by meiosis (Döpp, 1932; Manton, 1950; Mehra & Singh, 1957) or by mitosis (Evans, 1964) and production of a diploid or haploid sporophyte from a diploid or haploid gametophyte without an intervening act of syngamy. In many sexual species apogamous outgrowths from the gametophyte can be induced by abnormally prolonged cultural conditions. This type of reproduction in sexual species has not been observed in nature, and sporophytes produced in this manner in cultivation have not produced viable spores (Manton, 1950, p. 201). Further elaborations of the fern life-cycle include vegetative reproduction, which is found in a large number of species, and apospory, which has been produced in the laboratory but has yet to be shown conclusively to occur in nature (see DeBenedictis, 1969, for a review of literature on apogamy and apospory in ferns).

In addition to the obligate nature of the sexual or apogamous life-cycle, some species of homosporous ferns can be characterized as being high polyploids, a condition apparently evolved in response to the primarily homothallic nature of their gametophytic reproductive biology (Klekowski & Baker, 1966). As a result of this general dominant polyploid theme, base numbers of extant genera are themselves composed of several sets of duplicate chromosomes, with multivalent formation during meiosis restricted or eliminated by genetic or physiological control of bivalent pairing. Evidence is accumulating that the polyploid condition in ferns has selective advantage in that it provides storage of genetic information which is later released by homoeologous recombination (Klekowski, 1973).

It is the object of this paper to provide evidence from the life-cycle of a single plant of *Matteuccia orientalis* (Hooker) Trev. which circumstantially indicates the presence of facultative apomixis (the production of sporophytes from gametophytes by both sexual and apogamous pathways) and the production of both haploid spores and diploid spores with their subsequent germination and growth into gametophytes of two ploidy levels.

Matteuccia orientalis is an Asian species distributed from India throughout China to Siberia, Korea, and Japan. It consists of two cytotypes, a diploid ($n = 40$) found mostly on the Asian mainland and a tetraploid ($n = 80$) found in Japan. Lloyd (1971) shows that the tetraploid cytotype is of autoploid origin.

METHODS AND MATERIALS

Spore samples were collected from plants cultivated at the University of California Botanical Garden, Berkeley. These plants were originally collected by Dr. Y. Nozu, Botanical Institute, University of Tokyo, from Kisarazu, Chiba Prefec-

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ture, Japan. Spores were sown on sterile, inorganic nutrient medium solidified with 1% agar (see Klekowski, 1969, for composition of the medium). Gametophytes were grown under continuous illumination from white fluorescent and incandescent lamps at an intensity of about 220 ft-c at about 22° C. Spore morphology was studied by mounting spores in diaphane or in Hoyer's medium. Gametophyte morphology was studied by mounting prothalli in Hoyer's medium mixed with acetocarmine stain. Chromosome and nucleus studies were done on gametophytes either mounted in Hoyer's acetocarmine or fixed in 3:1 absolute ethanol:acetic acid and stained with acetocarmine.

Breeding tests were divided initially into three experiments: (1) twenty-five isolated gametophytes in small (60 × 15 mm) plastic petri plates, which were watered twice weekly; (2) twenty-five gametophytes in a single, composite population on a large (150 × 25 mm) petri plate, also watered twice weekly; (3) twenty-five gametophytes in a single, composite population in a large plate kept dry as an apogamous control. Later tests involved only unwatered, isolated gametophytes.

RESULTS

Breeding tests were conducted on *M. orientalis (Lloyd 4317)* as a segment of research pertaining to a study of breeding systems in the onocleoid ferns. Results of the initial breeding test of this organism indicated that in this material two phases of sporophyte production from gametophytes were present: an apparent sexual phase followed by an apparent apogamous phase. In the initial test, sporophyte production on watered plates (experiments 1 and 2) commenced 46 days following sowing. Ten days later, after 60% of the gametophytes of experiment 1 and 72% of those of experiment 2 had produced sporophytes, sporophyte production was initiated on the unwatered apogamous control plate (experiment 3). At the termination of these experiments (102 days after sowing), 36% of the gametophytes of experiment 3 had produced sporophytes.

Similar results were obtained in a duplicate breeding test using spores from the same parental source. In this test (breeding test one, *Table 1*) sporophytes appeared on the unwatered gametophytes of experiment 3 eight days following their appearance in experiments 1 and 2. At the termination of this test, 32% of the gametophytes of experiment 3 had produced sporophytes as compared to 90% and 92% sporophyte production respectively in experiments 1 and 2. A third breeding test was conducted (breeding test two, *Table 1*) similar in format to the above. Apparent apogamous sporophytes appeared seven days after sexual sporophytes, with 40% of the gametophytes of experiment 3 ultimately producing sporophytes.

As experiment 3 of the initial, first, and second tests was constructed with 25 gametophytes in a composite culture, two subsequent breeding tests (three and four) were devised utilizing isolated gametophytes on small, unwatered plates. Test three (*Table 1*) involved ten isolated gametophytes. In this test sporophytes appeared 76 days after sowing, and 50% of the gametophytes ultimately produced sporophytes. Test four involved 43 isolated, unwatered gametophytes; in this test 32.6% of the gametophytes produced sporophytes.

Gametophytes from breeding tests three and four were analyzed for the presence of gametangia. The normal condition in *M. orientalis* is for the gametophytes to produce archegonia three to four weeks after spore germination. The archegoniate phase lasts about 30 days, at the end of which time antheridia are initiated on the cushion in close proximity to archegonia, and the hermaphroditic condition is attained. In crowded cultures, initially male gametophytes may also be produced; these appear about 45 days following germination.

TABLE 1. BREEDING TESTS OF *Matteuccia orientalis* (*Lloyd 4317*) SHOWING TIME OF APPEARANCE AND NUMBER OF SPOROPHYTES.

	TEST ONE			TEST TWO	TEST THREE
Days from sowing	*Exp. 1*	*Exp. 2*	*Exp. 3*	*Exp. 3*	
68	2	1			
73	1				
75	1	2			
76			2	4	1
80	4	4	1	1	1
82	1				
86		1			
89	1				3
104				4	
112	1	2			
120	5	1		1	
123	1				
125	3	1			
131	2	2			
135			1		
139		1			
141			1		
146			1		
149	1	1	1		
152	1		1		
155	2				
159	1	7			
Number sown	30	25	25	25	10
No. & % produced	27(90%)	23(92%)	8(32%)	10(40%)	5(50%)

Observation of gametophytes in experiment 3 of the initial test (p. 44) indicated that prothalli which produced sporophytes appeared to be devoid of gametangia. Gametophytes in this experiment which bore archegonia did not produce sporophytes. In breeding test one (*Table 1*) gametophytes of experiment 1 and 2 which produced sporophytes between day 68 and 75 were found to be hermaphroditic. In experiment 3 of breeding test one (*Table 1*), all gametophytes produced numerous archegonia; however, only 20% of those which produced sporophytes were hermaphroditic. In breeding tests two and three all gametophytes of experiment 3 were unisexual and female. In breeding test four, 41 gametophytes were unisexual and female, one was hermaphroditic with several archegonia and two antheridia, and one (which had produced a sporophyte) was asexual.

The above data lead to the conclusion that *Lloyd 4317* possesses two mechanisms for sporophyte production: an initial phase where syngamy is possible due to the presence of both archegonia and antheridia and an aqueous medium, followed shortly by a second phase where syngamy is not possible due to the lack of hermaphroditism and a non-aqueous medium.

Sexual reproduction in ferns normally produces gametophytes with half the number of chromosomes as the sporophyte. In apogamous reproduction the chromosome number does not vary from sporophyte to gametophyte. Since the breeding tests indicate that perhaps both sexual and apogamous reproduction is taking place in *Lloyd 4317,* studies were made on nucleus diameters of the wing tissue of gametophytes and first frond blades of sporophytes produced during both phases, as an indicator of ploidy level. Gametophytes of experiments 1 and 2, which apparently produced sporophytes sexually during the earlier phase of production, exhibited nuclei which varied in diameter from 5.1μ to 12.5μ (mean = 7.67μ). Mean nucleus diameter for all measured gametophytes in experiments 1 and 2 varied from 5.9μ to 9.1μ. In contrast, nuclei of the gametophytes of experiment 3 were considerably larger and varied in diameter from 7.5μ to 17.5μ (mean = 11.83μ). Mean nucleus diameter for all measured gametophytes of experiment 3 varied from 11.2μ to 12.4μ. Sporophyte nucleus diameter from all experiments varied from 7.5μ to 17.5μ (mean = 11.88). Mean nucleus diameter for all sporophytes varied from 11.1μ to 12.9μ.

Confirmation of the ploidy level of the gametophytes was attempted by determining the chromosome number of individual prothalli utilizing the dividing cells of antheridial primordia. Although most prothalli did not yield proper division stages or sufficiently separated chromosomes for counting, two definitive counts were obtained, 40 and ca 80 at mitotic metaphase. These numbers were obtained in different gametophytes. In the remaining prothalli accurate counts were not obtained, although many exhibited numbers over 60.

Since data from the above studies indicate that two modes of sporophyte formation and at least two ploidy levels are present in the gametophytes of *Lloyd 4317,* an analysis was made of spore size and number per sporangium of the parent sporophyte. Spores in *Lloyd 4317* vary from 43.0μ to 95.0μ (mean = 67.0μ) long without the perispore and from 25.0μ to 83.0μ (mean = 45.0μ) wide. Comparative data from Lloyd (1971) indicates that spores in the diploid cytotype vary from 57.0μ to 85.0μ (mean = 70.0μ) long without the perispore and from 30.0μ to 60.0μ (mean = 48.0μ) wide; spores of tetraploids vary from 65.0μ to 95.0μ (mean = 79.0μ) long and from 37.5μ to 70.0μ (mean = 53.0μ) wide. Some spores of *Lloyd 4317* are as large as the largest of plants of the tetraploid cytotype, whereas others are smaller than those found in the diploid. Therefore, *Lloyd 4317* is unique among all examined material in producing spores which exhibit all of the size variation found in normal diploids and tetraploids. In addition, maximum variation in spore length in individual diploid and tetraploid plants was 20μ. In *Lloyd 4317,* maximum variation was 52μ.

Total spore size was estimated by calculating the combined length and width of each spore per sporangium. These totals were plotted using a histogram for dis-

tribution pattern. Of the 55 sporangia examined in *Lloyd 4317,* 33 exhibited normal distribution curves but with wide standard deviations. In the remaining sporangia, distribution patterns were more or less bimodal.

A comparative analysis was made of the number of fully formed spores per sporangium and the total number of spore bodies (fully formed and abortive) per sporangium in diploids, tetraploids, and *Lloyd 4317.* These data are given in *Table 2.* In normal diploid and tetraploid plants, 75% and 84% of the sporangia respectively exhibit 63 or 64 fully formed spores. In *Lloyd 4317,* 18.2% of the sporangia exhibit 63 or more fully formed spores. All the sporangia of diploid and tetraploid plants exhibit a minimum number of 57 and 59 fully formed spores, respectively. In *Lloyd 4317,* 23.6% of the sporangia exhibit less than 57 fully formed spores. The mean number of fully formed spores per sporangium in diploids, tetraploids, and *Lloyd 4317* is 62.8, 63.3, and 58.6 respectively.

TABLE 2. RELATIONSHIP OF SPORE NUMBER AND CONDITION TO PLOIDY LEVEL IN *Matteuccia orientalis.*

	Number and Percent of Sporangia		
Spore Number	*Diploid*	*Tetraploid*	*Lloyd 4317*
FULLY FORMED SPORES			
64	15 (45.5%)	34 (54.8%)	4 (7.3%)
63	10 (30.2%)	18 (29.1%)	6 (10.9%)
62	3 (9.1%)	6 (9.7%)	4 (7.3%)
61	3 (9.1%)	3 (4.8%)	6 (10.9%)
60	0	0	4 (7.3%)
59	0	1 (1.6%)	4 (7.3%)
58	1 (3.0%)		8 (14.5%)
57	1 (3.0%)		6 (10.9%)
46—56			13 (23.6%)
FULLY FORMED AND ABORTIVE SPORES			
64	25 (75.8%)	44 (71.0%)	8 (14.5%)
63	8 (24.2%)	14 (22.6%)	11 (20.0%)
62		4 (6.4%)	6 (10.9%)
61			5 (9.1%)
60			4 (7.3%)
52—59			21 (38.2%)

An analysis of the total number of spore bodies per sporangium indicates that in diploids and tetraploids over 93% of the sporangia studied have 63 or 64 bodies, whereas in *Lloyd 4317,* only 34.5% of the sporangia studied have 63 or 64 bodies and 38.2% have fewer than 60 bodies per sporangium. The mean number of bodies per sporangium in diploids, tetraploids, and *Lloyd 4317* is 63.7, 63.6, and 60.0, respectively.

DISCUSSION

Data from this study present an enigmatic pattern of reproductive biology in *Lloyd 4317.* Although much of the data is circumstantial, two basic phenomena unusual to leptosporangiate ferns can be documented: (1) the production of

gametophytes with two different chromosome numbers from the same sporophyte, and (2) biphasic sporophyte production from gametophytes where syngamy is not possible, correlated with no increase in nucleus size in resulting sporophytes, and from gametophytes where syngamy is possible, coupled with a corresponding increase in nuclei diameters in resulting sporophytes.

The mechanism for the production of gametophytes of two ploidy levels is best sought in the meiotic process or in those mitotic divisions which directly precede meiosis. Analysis of spore size and of spore number (normal and abortive) per sporangium indicates that meiosis in *Lloyd 4317* is irregular, especially when compared with that of normal diploids and tetraploids. Spore sizes which are realized in *Lloyd 4317* are as large as the largest of the tetraploid cytotype and smaller than those of the diploid. Spore size has commonly been used in ferns as an indicator of ploidy level, although perhaps not accurately. In this case, the wide variation in spore size, coupled with the common bimodal distribution patterns in many sporangia, correlates with the production of gametophytes with both 40 and 80 chromosomes. Evidence for the origin of both haploid and diploid spores is even more enigmatic. Examination of the data given in *Table 2* indicates that over 92% of the sporangia do not produce 64 normal spores, with 56.3% possessing 59 or fewer spores. An analysis of the data for the total number of normal and abortive spores per sporangium yields a similar trend, but one of less magnitude, with 85.5% of the sporangia with fewer than 64 and with 38.3% with 59 or fewer spores. The simplest meiotic mechanism which would account for both haploid and diploid gametophytes, small and large spores, and reduced number of spores per sporangium, is the formation of an occasional restitution nucleus in many sporangia, followed by the completion of meiosis. If this process is occurring in this organism, it is by no means regular, as evidenced by the wide variation in spore number per sporangium. This hypothesis is made on the assumption that the sporophyte is of the diploid cytotype of the species, as indicated by the overall spore measurements. It must be noted, however, that other plants from this population were found to be tetraploid and that the normal cytotype in Japan is the tetraploid.

LITERATURE CITED

DeBENEDICTIS, VIRGINIA M. 1969. Apomixis in ferns with special reference to sterile hybrids. Ph.D. Dissertation, Univ. of Michigan, Ann Arbor.

DÖPP, W. 1932. Die Apogamie bei Aspidium remotum A. Br. Planta **17:** 86–152.

EVANS, A. M. 1964. Ameiotic alternation of generations: a new life cycle in ferns. Science **143:** 261–263.

KLEKOWSKI, E. J., JR., 1969. Reproductive biology of the Pteridophyta, III. The Blechnaceae. Bot. J. Linn. Soc. **62:** 360–377.

————. 1973. Sexual and subsexual systems in homosporous pteridophytes: a new hypothesis Amer. J. Bot. (In press).

————, and H. G. BAKER. 1966. Evolutionary significance of polyploidy in the Pteridophyta. Science **153:** 305–307.

LLOYD, R. M. 1971. Systematics of the onocleoid ferns. Univ. Calif. Pub. Bot. **61:** 1–93.

MANTON, I. 1950. Problems of cytology and evolution in the Pteridophyta. Cambridge.

MEHRA, P. N. and G. SINGH. 1957. Cytology of Hymenophyllaceae. J. Genetics **55:** 379–393.

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American Fern Journal

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The "American Fern Journal" is an illustrated quarterly devoted to the general study of ferns. It is owned by the American Fern Society, and published at 3200 Falls Cliff Rd., Baltimore, Md. 21211. Second-class postage paid at Baltimore.

Matter for publication and claims for missing numbers (made within six months of the date of issue) should be addressed to the Editor-in-Chief.

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Subscriptions $5.50 gross, $5.00 net (agency fee $0.50); sent free to members of the American Fern Society (annual dues, $5.00; sustaining membership, $10.00; life membership, $100.00). Extracted reprints, if ordered in advance, will be furnished to authors at cost, plus postage.

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Conrad Vernon Morton (1905–1972)[1]

DAVID B. LELLINGER*

Conrad Vernon Morton, named Walter Vernon Morton at the time of his birth on October 24, 1905, was the son of Walter Crow Morton and Nioma (later Noma) Bartholomew Morton. He was born in Fresno, California, where his parents had been life-long residents and his father had a roofing and building contractor's business. Walter Crow Morton died when Walter was still young, and in about 1917 his mother married Alva B. McCray, who also had been a resident of Fresno for many years. In fact, the McCray and Bartholomew families were friends. Mr. McCray was employed by the Santa Fe Railroad. The family home at Fresno included a vineyard and various gardens on the property, and so young Walter was introduced to plants at an early age. As a child, he planted and tended a small garden of his own. His mother was well known in the area for her rose garden; she grew about 130 varieties abundantly.

During his junior high and high school years, the family lived in Berkeley, where Mrs. McCray's sister and family lived. The climate there was more moderate than in Fresno, and better for Mrs. McCray's health. When he was in high school Walter won a fellowship to the local Art Institute. Of all the students in the class, he was the only boy, and for this reason he did not pursue his study of art very far at that time. (After he began his professional career, however, he studied both painting and the piano diligently, and mastered and practiced both arts with great pleasure for himself and his friends for the remainder of his life. He was also greatly interested in the history of the cinema, in dramatics, and in philately. For a more ample account of Morton's non-botanical interests, see Ewan, J. A. 1973. Taxon **22:** 271–274.)

Morton entered the University of California at Berkeley in 1924. At that time he changed his given names to Conrad Vernon (the legal change was made on April 14, 1926). His interests at first included the physical sciences, mathematics, astronomy, and slavic languages and literature. During the latter part of his freshman year he began a course in general botany. In his sophomore year he studied elementary taxonomy under Prof. Willis L. Jepson. Apparently this course triggered a strong interest in taxonomic botany, for he took several more courses from Jepson, plus algology and mycology from Prof. Gardner, plant physiology from Prof. Holman, and cytology and genetics from Prof. Goodspeed. His first botanical collections were made around Berkeley in January 1926. Morton held tuition scholarships at the University for the last three of his undergraduate years. He was a Levi Strauss Scholar in 1925–26, a Henry Morgan Holbrook Scholar in 1926–27, and a Carrie M. Jones Scholar in 1927–28. He was elected to membership in the scientific fraternity Sigma Xi and in the biological sciences fraternity Phi Sigma. In October 1926 he was inducted into

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[1] I am indebted to Mr. Morton's sister, Mrs. Howard King, for most of the details of his early years.

Volume 63, number 2, of the Journal, pp. 25–48, was issued June 22, 1973.

C. V. Morton at the Arnold Arboretum centennial celebration, May 1972 (photo by W. H. Hodge).

the Alpha chapter, California, Phi Beta Kappa. He received a Bachelor of Arts degree *cum laude* from the University of California in May 1928.

After he graduated, he was appointed a Teaching Fellow in Botany for the summer session, but he resigned to take a position as Phanerogamic Aid in the Division of Plants, U. S. National Museum, Smithsonian Institution. Prof. Jepson wrote a highly favorable recommendation in his behalf.

In his early years at the Smithsonian, Morton worked on flowering plants in general. His first assignment, he once told me, was to identify some specimens from North Africa. This, in the face of scant literature and fewer specimens, was apparently a kind of an initiation—which he surmounted. Much of his time was taken up with identification of phanerograms from the western United States, the Caribbean, Mexico, and Central America. He soon took up the Gesneriaceae and Solanaceae as specialties; both became life-long interests. He spent the spring of 1933 making general collections in Oaxaca, Mexico. On this trip he fell ill with malaria, which recurred from time to time in succeeding years. In 1936 and 1941 he took collecting trips to Cuba. Besides his research interests, he did thousands of identifications, helped to curate the herbarium, began to compile an Index Generum to the flowering plants (which was not completed), and made indices to some of the larger fern genera in the New World based on the "Index Filicum" and the "Gray Herbarium Card Index." In 1939 he was appointed an Assistant Curator of Phanerogams in the Division of Plants. He also began to take post-graduate courses in botany at nearby George Washington University. Although he did not hold a Master's Degree, he was admitted to the doctoral program on the strength of several lengthy scientific papers which he had published previously.

Although he had published on ferns occasionally since 1932, in the middle 1930's he began to devote more and more of his time to research on and identification of the ferns, under the guidance of Dr. William R. Maxon, who was a fern specialist and the Curator of the Division of Plants.

After Maxon's retirement in 1946, the Division of Plants was reorganized as the Department of Botany. Morton was appointed Associate Curator of the Division of Ferns. At this time he withdrew from the doctoral program at George Washington University due to the press of official duties. The following year he made extensive general collections on the island of St. Vincent and explored a newly discovered valley in the mountainous interior of the island. In 1948 he was appointed Curator of the Division of Ferns, a position he held until 1970. From 1948 to 1959 he also held the title of Acting Curator of the Division of Cryptogams. This was a period of severe staff shortages, and his role in that Division did not extend beyond maintaining the collections.

From 1950 to 1954 Morton was a member of the International Botanical Congress Committee on Nomenclature. In 1951 he accompanied Dr. L. O. Williams on a field trip to Honduras. The fern specimens from this trip were to help form the basis for a fern Flora of that country, but the project remained in rough manuscript, as did a similar project on the ferns of Guatemala.

Morton realized that the biggest difficulty in preparing tropical fern floristic works was inadequate nomenclatural research. He knew that long trips to study in European herbaria would be necessary to produce adequate treatments of the ferns. He applied for and in 1954 received a Simon Guggenheim Foundation fellowship to study type specimens of ferns in European herbaria. The National Science Foundation awarded him grants for the same purpose in 1957 and 1963. He searched portions of the herbaria at Berlin, Brussels, Copenhagen, Edinburgh, Florence, Geneva, Hamburg, Kew, Leiden, Liverpool, London (British Museum), Oslo, Oxford, Munich, Paris, Stockholm, Utrecht, Vienna, and Zurich, and took more than 22,000 photographs, including some in his phanerogamic specialties. The greatest value in these photographs has been his painstaking literature and taxonomic work and typifications, which the often extensive labels that accompany the photographs reflect.

In 1956 he took a third and last field trip to Cuba. From that time on he was quite fully occupied with administrative, research, and identification duties. Occasionally he attended field forays sponsored by the American Fern Society. He also took several pack trips in the western United States, but these were an extension of his interest in wilderness and its conservation, and were not undertaken from a botanical standpoint. In 1961 he suffered the first of a series of heart attacks. For a decade he felt that these precluded further field work. Despite his afflictions, which included almost the entire loss of eyesight in one eye due to a detached retina, he continued to work steadily in the herbarium and to take frequent trips to other herbaria.

From the early 1960's he mostly worked on ferns, and for a time did little with his phanerogamic specialties. He headed the International Botanical Congress Special Committee for the Study of Superfluous Names during its period of activity in 1968 and 1969. In June 1970 he represented the Smithsonian Institution at the tercentenary celebration of the Royal Botanic Garden, Edinburgh. He greatly enjoyed a tour which visited gardens all over Scotland. In 1970 he was made a Senior Botanist, which freed him from administrative duties. He returned to his interest in the Solanaceae and began to complete a manuscript on Argentine *Solanum*. He was awarded a Smithsonian Research Foundation grant for field work and herbarium study in Argentina, and spent three months there in early 1972. Upon his return from the field, he continued to work hard on his *Solanum* manuscript and seemed to be in rather better health than usual, but a few months later, on July 29, 1972, he passed away unexpectedly at his home in Washington.

Morton was an honorary life member of the American Gesneria Society and an honorary member of the American Fern Society. He served as associate editor of the "American Fern Journal" from 1941 to 1947 and from 1962 to 1972. He was the editor-in-chief from 1948 to 1961. He is commemorated by the genera *Mortoniella* Woodson and *Mortoniodendron* Standl., and by the names *Asplenium mortonii* Duek, *Banisteria sprucei* var. *mortoniana* Macbr., *Besleria mortoniana* Steyerm., *Capsicum mortonii* Raymond, *Clidemia mortoniana* Standl.,

Columnea mortonii Raymond, *Cyphomandra mortoniana* Smith & Downs, *Erigeron mortonianum* Reveal, *Eupatorium* × *mortonianum* Alain, *Gesneria mortonii* Wiehler, *Hiraea sprucei* var. *mortoniana* Macbr., *Inga mortoniana* Leon, *Milla mortoniana* Moore, *Niphidium mortonianum* Lellinger, *Schoenocaulon mortonii* Brinker, *Selaginella mortoniana* Crabbe & Jermy, *Tetrapteris jamesonii* var. *mortonii* Macbr. [= *T. mortonii* (Macbr.) Cuatr.], *Thelypteris mortoniana* A. Reid Smith, *Tigridia mortonii* Molseed, *Topobea mortoniana* Wurdack, *Viburnum mortonianum* Standl. & Steyerm., *Witheringia mortonii* Hunziker, *Xiphopteris mortonii* Copel., and *Microgramma mortoniana* de la Sota.

BIBLIOGRAPHY OF C. V. MORTON

(excluding minor reviews and ephemeral notes)

1. A new species of Esenbeckia from Texas. J. Washington Acad. Sci. **20:** 135–136. 1930.
2. A new species of Calathea from Panama. J. Washington Acad. Sci. **20:** 372–374. 1930.
3. A new Banisteria from Brazil and British Guiana. Proc. Biol. Soc. Washington **43:** 157–160. 1930.
4. A new cannon-ball tree from Panama. J. Washington Acad. Sci. **20:** 396–398. 1930.
5. Two new species of Meibomia from Mexico. Bull. Torrey Bot. Club **57:** 181–182. 1930.
6. A new Oreobroma from the Trinity Mountains of California. Proc. Biol. Soc. Washington **44:** 9–10. 1931.
7. The genus Lozanella. J. Washington Acad. Sci. **21:** 336–339. 1931. (with E. P. Killip)
8. Solanaceae *in* H. A. Gleason, Botanical results of the Tyler-Duida Expedition. Bull. Torrey Bot. Club **58:** 465–466. 1931.
9. Notes on Yagé, a drug plant of southeastern Colombia. J. Washington Acad. Sci. **21:** 485–488. 1931.
10. A new species of Hymenophyllum from Peru. J. Washington Acad. Sci. **22:** 63–65. 1932.
11. Goebel's "Roraima Ferns." Amer. Fern J. **22:** 19–23. 1932.
12. Five new South American species of Mascagnia. Proc. Biol. Soc. Washington **45:** 49–54. 1932.
13. A new species of Adenostegia from Death Valley, with notes on calyx structure in the genus. J. Washington Acad. Sci. **22:** 160–166. 1932.
14. Buesia, a new subgenus of Hymenophyllum from Peru. Bot. Gaz. **93:** 336–339. 1932.
15. A new species of Mascagnia from Colombia. Phytologia **1:** 19. 1933. (with H. N. Moldenke)
16. A new species of Peltostigma from Mexico. Proc. Biol. Soc. Washington **46:** 83–84. 1933.
17. A new species of Rajania from Cuba. Proc. Biol. Soc. Washington **46:** 85–86. 1933.
18. Two new species of Hiraea from Colombia. Proc. Biol. Soc. Washington **46:** 87–90. 1933.
19. A remarkable new Trifolium from Washington. J. Washington Acad. Sci. **23:** 270–271. 1933.
20. Solanaceae *in* H. A. Gleason and A. C. Smith, Plantae Krukoffianae. Bull. Torrey Bot. Club **60:** 356–357. 1933.
21. A new Silene from Washington. Torreya **33:** 70–71. 1933. (with J. W. Thompson)
22. The Mexican and Central American species of Viburnum. Contr. U. S. Nat. Herb. **26:** 339–366. 1933.
23. A new maidenhair from Peru. Amer. Fern J. **24:** 15–17. 1934. (with W. R. Maxon)
24. A new species of Dudleya from Arizona. Desert Plant Life **6:** 68. 1934.
25. The genus Besleria in Venezuela. Proc. Biol. Soc. Washington **48:** 73–76. 1935.

26. Synopsis of the species of Besleria in Ecuador. Proc. Biol. Soc. Washington **48:** 55–58. 1935.
27. The genus Cremosperma. J. Washington Acad. Sci. **25:** 284–291. 1935.
28. A new species of Maurandia from Death Valley. J. Washington Acad. Sci. **25:** 291–293. 1935. (with F. V. Coville)
29. Three new plants from Death Valley, California. J. Washington Acad. Sci. **25:** 307–311. 1935.
30. The genus Besleria in British Guiana. Phytologia **1:** 151–153. 1935.
31. New species of plants from Guatemala. Phytologia **1:** 145–150. 1935.
32. A checklist of the bulbous Amaryllidaceae native to the United States. Yearbook Amer. Amaryllis Soc. 80–84. 1936.
33. Enumeration of the Malpighiaceae of the Yucatan Peninsula. Carnegie Institution Publ. **461:** 125–140. 1936.
34. Notes on Dioscorea, with special reference to the species of the Yucatan Peninsula. Carnegie Institution Publ. **461:** 239–253. 1936.
35. A revision of the Mexican and Central American species of Smilax. Carnegie Institution Publ. **461:** 255–296. 1936. (with E. P. Killip)
36. New Gesneriaceae *in* Contributions to the flora of tropical America: XXV. Kew Bull. Misc. Inf. **1936:** 11–16. 1936.
37. Eriogonum intrafractum, a new species and a new subgenus from Death Valley, California. J. Washington Acad. Sci. **26:** 303–306. 1936. (with F. V. Coville)
38. The genus Cestrum in Guatemala. J. Arnold Arbor. **17:** 341–349. 1936.
39. Some Guatemalan species of Viburnum. Proc. Biol. Soc. Washington **49:** 153–154. 1936.
40. The correct name of the leafy spurge. Rhodora **39:** 49–50. 1937.
41. The correct names of the small-flowered mallows. Rhodora **39:** 98–99. 1937.
42. New species of Costa Rican plants. J. Washington Acad. Sci. **27:** 304–312. 1937.
43. A new species of Dryopteris, subgenus Eudryopteris, from Guatemala. Proc. Biol. Soc. Washington **50:** 178–180. 1937. (with W. R. Maxon)
44. A checklist of the bulbous Amaryllidaceae of Mexico. Herbertia **4:** 101–108. 1937.
45. Cruciferae *in* E. H. Graham, Botanical studies in the Uinta Basin of Utah and Colorado. Ann. Carnegie Mus. **26:** 220–221. 1937.
46. Gesneriaceae *in* R. E. Woodson and R. J. Seibert, Contributions toward a flora of Panama. Ann. Missouri Bot. Gard. **24:** 202–205. 1937.
47. Notes on the genus Saracha. Proc. Biol. Soc. Washington **51:** 75–78. 1938.
48. The American species of Dryopteris, subgenus Meniscium. Bull. Torrey Bot. Club **65:** 347–376. 1938. (with W. R. Maxon)
49. Notes on Cremosperma. J. Washington Acad. Sci. **26:** 348–349. 1938.
50. A new Viburnum from Mexico. Proc. Biol. Soc. Washington **51:** 215–216. 1938.
51. New Mexican Gesneriaceae *in* Contributions to the flora of tropical America: XXXVI. Kew Bull. Misc. Inf. **1938:** 292–294. 1938.
52. New South American species of Dryopteris, section Glaphyropteris. J. Washington Acad. Sci. **28:** 525–530. 1938.
53. Solanaceae *in* P. C. Standley, Flora of Costa Rica. Field Mus. Publ. Bot. **18:** 1035–1099. 1938. (with P. C. Standley)
54. Gesneriaceae *in* P. C. Standley, Flora of Costa Rica. Field Mus. Publ. Bot. **18:** 1137–1187. 1938.
55. A revision of the genus Besleria. Contr. U. S. Nat. Herb. **26:** 395–474. 1939.
56. On the genus Cyclodium. Bull. Torrey Bot. Club **66:** 47–52. 1939.
57. New ferns from Bolivia and Peru. Bull. Torrey Bot. Club **66:** 39–45. 1939. (with W. R. Maxon)
58. Our southwestern resurrection plants. Amer. Fern J. **29:** 14–16. 1939.
59. Notes on Elaphoglossum, I. Amer. Fern J. **29:** 10–14. 1939.
60. A second United States species of Bernardia. J. Wash. Acad. Sci. **29:** 375–377. 1939.

61. Gesneriaceae *in* R. E. Woodson and R. J. Seibert, Contributions to the flora of Panama, III. Ann. Missouri Bot. Gard. **26:** 308–313. 1939.
62. Solanaceae *in* C. L. Lundell, Studies of tropical American plants. I. Contr. Univ. Michigan Herb. **4:** 24–27. 1940.
63. A checklist of Amaryllidaceae, Tribe Allieae, in the United States. Herbertia **7:** 68–83. 1940.
64. On the Florida fern known as Dryopteris setigera. Amer. Fern J. **31:** 12–14. 1941.
65. A note on Halogeton. Leafl. West. Bot. **5:** 45–46. 1941.
66. On the name of the oak-fern. Rhodora **43:** 216–219. 1941.
67. Notes on Juniperus. Rhodora **43:** 344–348. 1941.
68. Isoëtaceae *in* R. E. Woodson and R. J. Seibert, Contributions to the flora of Panama. Ann. Missouri Bot. Gard. **26:** 272. 1939. (with W. R. Maxon)
69. New Gesneriaceae from Panama. Ann. Missouri Bot. Gard. **29:** 35–58. 1942.
70. Smilacaceae *in* R. E. Woodson and R. W. Schery, Contributions to the flora of Panama. Ann. Missouri Bot. Gard. **29:** 326. 1942.
71. Localidades visitadas y rutas recorridas por E. W. Nelson en el Estado de Oaxaca. Anal. Inst. Biol. Mexico **13:** 47–51. 1942. (with R. E. Schultes)
72. Note on Dryopteris celsa. Amer. Fern J. **33:** 141–142. 1943.
73. A new Trichomanes from Colombia. Amer. Fern J. **34:** 19–20. 1944.
74. Taxonomic studies of tropical American plants. Contr. U. S. Nat. Herb. **29:** 1–86. 1944.
75. A note on Eriogonum. Leafl. West. Bot. **4:** 47. 1944.
76. Smilacaceae and Dioscoreaceae *in* R. E. Woodson and R. W. Schery, Flora of Panama. Ann. Missouri Bot. Gard. **32:** 6–11, 26–33. 1945.
77. A new species of Markea from Colombia. Proc. Biol. Soc. Washington **58:** 1–2. 1945.
78. Seven new species of Gesneriaceae from Peru and Colombia. J. Washington Acad. Sci. **35:** 126–131. 1945.
79. Mexican phanerogams described by M. E. Jones. Contr. U. S. Nat. Herb. **29:** 87–116. 1945.
80. A genus new to North America. Leafl. West Bot. **4:** 164–165. 1945.
81. New species of Pilea from Cuba. Rev. Soc. Cubana Bot. **2:** 1–8. 1945.
82. Una nueva especie Peruana de Saracha. Rev. Univ. Cuzco **87:** 96–97. 1945.
83. Las especies Sudamericanas del género Monopyle. Rev. Univ. Cuzco **87:** 98–116. 1945.
84. A new species of Isoëtes from Colombia. Amer. Fern J. **35:** 48–49. 1945.
85. The fern studies of Mirbel. J. Washington Acad. Sci. **36:** 166–169. 1946.
86. Two new ferns from Colombia. Amer. Fern J. **36:** 91–94. 1946. (with W. R. Maxon)
87. The American species of Hymenophyllum, section Sphaerocionium. Contr. U. S. Nat. Herb. **29:** 139–201. 1947.
88. Some notes on Hawaiian Asplenieae. Amer. Fern J. **37:** 114–119. 1947.
89. Pteridophyta *in* B. Maguire, Plant Explorations in Guiana in 1944, chiefly to the Tafelberg and the Kaieteur Plateau, I. Bull. Torrey Bot. Club **75:** 66–79. 1948. (with W. R. Maxon)
90. Gesneriaceae *in* B. Maguire, Plant Explorations in Guiana in 1944, chiefly to the Tafelberg and the Kaieteur Plateau, V. Bull. Torrey Bot. Club **75:** 563–566. 1948.
91. Bibliography of William R. Maxon. Amer. Fern J. **38:** 106–117. 1948. [1949].
92. Notes on Elaphoglossum, II. The species of the French West Indies. Amer. Fern J. **38:** 202–214. 1948 [1949].
93. A new Brunfelsia from Brazil. Proc. Biol. Soc. Washington **62:** 151–152. 1949.
94. Index of illustrations, American Fern Journal, volumes 1–38. Amer. Fern J. **39:** 75–82. 1949.
95. Notes on the ferns of the eastern United States. Amer. Fern J. **40:** 213–225, 241–252. 1950.
96. Willard Nelson Clute. Amer. Fern J. **41:** 1–4. 1951.

97. Pteridophyta *in* J. A. Steyermark, Contributions to the flora of Venezuela. Fieldiana **28:** 7–16. 1951.
98. A new Jamaican species of Hemitelia. Amer. Fern J. **41:** 48–51. 1951. (with G. R. Proctor)
99. New combinations in Equisetum and Pellaea. Leafl. West. Bot. **6:** 156. 1951.
100. A new fern of the genus Danaea from Colombia. J. Washington Acad. Sci. **41:** 276. 1951.
101. A fern new to the United States. Amer. Fern J. **41:** 86–87. 1951.
102. Ferns and fern allies *in* T. H. Kearney and R. H. Peebles, Arizona Flora, pp. 27–49. 1951.
103. Pteridophyta *in* H. A. Gleason, Illustrated flora of the northeastern United States and adjacent Canada **1:** 1–56. 1952.
104. The generic name Anetium. Amer. Fern J. **43:** 71. 1953.
105. Gesneriaceae *in* J. A. Steyermark, Contributions to the flora of Venezuela. Fieldiana **28:** 520–534 1953.
106. A range extension in Cystopteris. Amer. Fern J. **43:** 125–126. 1953.
107. The eastern United States varieties of Equisetum hyemale. Amer. Fern J. **43:** 170–173. 1953 [1954].
108. A new Thelypteris from Ecuador. Amer. Fern J. **43:** 173–174. 1953 [1954].
109. Two misinterpreted tropical American ferns. Amer. Fern J. **43:** 174–175. 1953 [1954].
110. A proposal to remove the name Nothoscordum from the list of Nomina Conservanda. Taxon **3:** 21–22. 1954.
111. Proposed amendment to Article 24 of the International Code of Botanical Nomenclature. Taxon **3:** 22–23. 1954.
112. Dryopteris austriaca var. intermedia. Amer. Fern J. **44:** 16–18. 1954. (with C. Neidorf)
113. The hay-scented fern, Dennstaedtia punctilobula. Amer. Fern J. **44:** 65–68. 1954. (with C. Neidorf)
114. Polypodium vulgare var. virginianum. Amer. Fern J. **44:** 111–114. 1954. (with C. Neidorf)
115. A note on a species of Cyathea. Amer. Fern J. **44:** 147–148. 1954.
116. Gesneriaceae *in* Trin. Dept. Agr., Flora of Trinidad and Tobago **2:** 301–315. 1954.
117. Notes on Elaphoglossum, III. The publication of Elaphoglossum and Rhipidopteris. Amer. Fern J. **45:** 11–14. 1955.
118. The northern beech-fern. Amer. Fern J. **45:** 17–19. 1955. (with C. Neidorf)
119. Notes on Adiantum in Mexico, I. Amer. Fern J. **45:** 113–117. 1955.
120. The ferns described by Sessé and Mociño. Amer. Fern J. **45:** 151–156. 1955. (with W. R. Maxon)
121. The type of Blechnum cartilagineum. Amer. Fern J. **45:** 125–126. 1955.
122. The generic names Isoloma and Kohleria. The Gloxinian **5**(6): 16. 1956.
123. The Virginia chain-fern. Amer. Fern J. **46:** 28–30. 1956. (with C. Neidorf)
124. Three new Gesneriaceae from Panama. Proc. Biol. Soc. Washington **69:** 193–196. 1956.
125. Tree-ferns in western Mexico. Amer. Fern J. **46:** 146–148. 1956 [1957].
126. A new name for an Asplenium hybrid. Amer. Fern J. **46:** 152–155. 1956 [1957].
127. Hart's-tongue in Michigan again. Amer. Fern J. **46:** 157–158. 1956 [1957].
128. A species of Rechsteineria new to science and to cultivation. The Gloxinian **6**(3): 14–16. 1956.
129. The misuse of the term taxon. Rhodora **59:** 43–44. 1957. (reprinted in Taxon **6:** 155. 1957)
130. Pteridophyta *in* J. A. Steyermark, Contributions to the flora of Venezuela. Fieldiana **29:** 719–757. 1957.
131. Some West Indian Gesneriaceae. Brittonia **9:** 18–24. 1957.
132. Observations on cultivated ferns, I. Amer. Fern J. **47:** 7–14. 1957.
133. Gesneriaceae *in* Hno. León and Hno. Alain, Flora de Cuba, Vol. 4. pp. 451–472. 1957.

134. Observations on cultivated ferns, II. The proper generic name of the holly fern. Amer. Fern J. **47:** 52–55. 1957.
135. A further note on Scaevola. Field and Laboratory **25:** 79. 1957.
136. Observations on cultivated ferns, III. The species of Microlepia. Amer. Fern J. **47:** 102–108. 1957.
137. Ferns of the Galapagos Islands. Leafl. West. Bot. **8:** 188–195. 1957.
138. The fern genus Anopteris. Bull. Jard. Bot. Bruxelles **27:** 579–584. 1957.
139. Observations on cultivated ferns, IV. The species of Davallia. Amer. Fern J. **47:** 143–148. 1957.
140. Ferns and fern allies. Encyclopedia Americana **11:** 131–137. 1957.
141. Beitrag zur Pteridophyten-Flora von Mittelamerika. Neue Pteridophyten für Salvador II. Senckenbergiana Biologica **39**(1-2): 127–131. 1958. (with W. Lötschert)
142. Observations on cultivated ferns, V. The species and forms of Nephrolepis. Amer. Fern J. **48** 18–27. 1958.
143. Diplazium japonicum naturalized in Florida. Amer. Fern J. **48:** 28–30. 1958. (with R. K. Godfrey)
144. The identity of Polypodium viride Gilbert. Amer. Fern J. **48:** 75–77. 1958.
145. The Californian species of Thelypteris. Amer. Fern J. **48:** 136–142. 1958.
146. The new edition of the International Code of Botanical Nomenclature. Amer. Inst. Biol. Sci. Bull. **8**(5): 24–26. 1958.
147. A new Ampelocera from Cuba. Proc. Biol. Soc. Washington **71:** 153–154. 1958.
148. Nomenclature proposals for the Montreal Congress. Taxon **8:** 11–16. 1959.
149. Proposal to conserve the name Gerardia L. sensu Bentham 1835 against Gerardia L. 1753. Taxon **8:** 28. 1959.
150. A proposal regarding the conserved name Sphenomeris. Taxon **8:** 29. 1959.
151. Some casual notes on the new code of nomenclature. Taxon **8:** 37–40. 1959.
152. Some Cuban Gesneriaceae. The Gloxinian **8**(4): 18–21. 1959.
153. Frederick Louis Fagley, 1879–1959. Amer. Fern J. **49:** 65–66. 1959.
154. The identification of a Costa Rican Blechnum. Amer. Fern J. **49:** 66–69. 1959.
155. Remarks on some 1958 dealers' catalogs. Amer. Fern J. **49:** 72–76. 1959.
156. Two new species of Columnea in cultivation. Baileya **7:** 55–61. 1959.
157. Supplementary note on Columnea moorei. Baileya **7:** 101. 1959.
158. Sur la nomenclature de deux fougères rare d'Espagne. Bull. Soc. Bot. France **106:** 231–234. 1959.
159. Some new combinations in Thelypteris. Amer. Fern J. **49:** 113–114. 1959.
160. The correct name of the fern usually called Alsophila blechnoides. Amer. Fern J. **49:** 151–153. 1959.
161. Pteridophyta *in* The Machris Brazilian Expedition, Botany. Los Angeles County Mus. Contr. Sci. **35:** 3–7. 1960.
162. Observations on cultivated ferns, VI, The ferns currently known as Rumohra. Amer. Fern J. **50:** 145–155. 1960.
163. Some fern books for different regions of the United States. Amer. Fern J. **50:** 169–178. 1960.
164. Effective publication by Xerox? Taxon **9:** 192. 1960.
165. Pteridophyta *in* T. H. Kearney and R. H. Peebles, Arizona Flora, Suppl. pp. 1035–1037. 1960.
166. Taxonomic notes on ferns, I. Amer. Fern J. **50:** 275–276. 1960.
167. Taxonomic notes on ferns, II. Amer. Fern J. **51:** 37–39. 1961.
168. Some forms of Polypodium californicum. Amer. Fern J. **51:** 73–75. 1961.
169. Another genus of ferns new to the United States. Amer. Fern J. **51:** 81–83. 1961.
170. Another name change for the Florida fern known as Dryopteris setigera. Amer. Fern J. **52:** 27–29. 1962.

171. Gesneriaceae *in* J. A. Steyermark and S. Nilsson, Botanical novelties in the region of Sierra de Lema, Estado Bolívar–I. Bol. Soc. Venez. Cienc. Nat. **23:** 76–83. 1962.
172. Una nueva variedad de la especie Napeanthus subacaulis de Venezuela. Bol. Soc. Venez. Cienc. Nat. **23:** 98. 1962.
173. A new species of Achimenes, section Dicyrta. Baileya **10:** 49–52. 1962.
174. A reexamination of Mexican Smilax (Smilacaceae). Brittonia **14:** 299–309. 1962.
175. Pteridophyta *in* W. K. W. Baldwin, Report on botanical excursion to the boreal forest region in northern Quebec and Ontario. pp. 77–87. Department of Northern Affairs and National Resources, Canada, 1962.
176. The species of Achimenes, section Dicyrta. Baileya **10:** 147–154. 1962.
177. Taxonomic notes on ferns, III. Amer. Fern J. **52:** 148–150. 1962.
178. Another Columnea new to cultivation. Baileya **11:** 23–27. 1963.
179. Some West Indian species of Thelypteris. Amer. Fern J. **53:** 57–70. 1963.
180. Observations on cultivated ferns, VII. The Mother Ferns. Amer. Fern J. **53:** 81–84. 1963.
181. A revision of Trichantha (Gesneriaceae). Contr. U. S. Nat. Herb. **38**(1): 1–27. 1963.
182. The classification of Thelypteris. Amer. Fern J. **53:** 149–154. 1963.
183. Paul C. Standley and his work as revealed through his letters *in* L. O. Williams (ed.), Homage to Standley. pp. 7–22. Chicago Nat. Hist. Mus. 1963.
184. New combinations in Lycopodium. Amer. Fern J. **54:** 71–73. 1964.
185. The nomenclature of a Madagascarian Platycerium. Baileya **12:** 36–38. 1964.
186. A new Jamaican Cyathea. Amer. Fern J. **55:** 30–32. 1965.
187. Una Gesnesiaceae nueva de Venezuela. Bol. Soc. Venez. Cienc. Nat. **26:** 156–158. 1965.
188. A new generic name in the Saxifragaceae. Leafl. West. Bot. **10:** 181. 1965.
189. Observations on cultivated ferns, VIII. Stenochlaena. Amer. Fern J. **55:** 164–166. 1966.
190. Varieties of Ballota nigra in the eastern United States. Rhodora **68:** 93–94. 1966.
191. Gesneriaceae *in* J. A. Steyermark and G. Agostini, Exploración botánica del Cerro Patao y zonas adyacentes a Puerto Hierro, en la Peninsula de Paria, Edo. Sucre. Acta Bot. Venez. **1:** 65–74. 1966.
192. The Polypodiaceae subfamily Asplenioideae in Venezuela. Mem. N. Y. Bot. Gard. **15:** 1–49. 1966. (with D. B. Lellinger)
193. The United States National Herbarium. Pl. Sci. Bull. **12**(2): 1–4. 1966. (with W. L. Stern)
194. The validity of the generic name Ctenopteris. Amer. Fern J. **56:** 65–68. 1966.
195. The use of climing fern, Lygodium, in weaving. Amer. Fern J. **56:** 79–81. 1966.
196. The Mexican species of Tectaria. Amer. Fern J. **56:** 120–137. 1966.
197. Apospory in Pteris. Amer. Fern J. **56:** 139–140. 1966.
198. A new name for a Mexican grass. Leafl. West. Bot. **10:** 327. 1966.
199. Some new combinations in Thelypteris. Amer. Fern J. **56:** 177–179. 1966.
200. Is Thelypteris parasitica in cultivation in the United States? Amer. Fern J. **56:** 184–185. 1966.
201. Dipteris [nomen conservandum propositum]. Taxon **16:** 71–72. 1967.
202. A proposal to conserve the generic name Banisteria H.B.K. Taxon **16:** 74–76. 1967.
203. Proposal to conserve the generic name Thryallis Mart. Taxon **16:** 76–77. 1967. (with J. Cuatrecasas)
204. Ceratopteris thalictroides, a fern new to Texas. Amer. Fern J. **57:** 13–14. 1967.
205. The valid publication of Cheilanthes villosa. Amer. Fern J. **57:** 33–35. 1967.
206. On the publication of names by means of illustrations with analyses. Taxon **16:** 119–121. 1967.
207. Notes on the ferns of Dominica and St. Vincent. Amer. Fern J. **57:** 66–77. 1967. (with D. B. Lellinger)
208. Studies of fern types, I. Contr. U. S. Nat. Herb. **38**(2): 29–83. 1967.
209. Freeman and Curtis' account of the Red River Expedition of 1806, an overlooked publication of botanical interest. J. Arnold Arb. **48:** 431–459. 1967.

210. Selaginella apus or apoda? Amer. Fern J. **57:** 104–106. 1967.
211. The genus Grammitis in Ecuador. Contr. U. S. Nat. Herb. **38**(3): 85–123. 1967.
212. The genus Kohleria in Mexico [Gesneriaceae]. Baileya **15:** 61–78. 1967.
213. A new Kohleria from Costa Rica in cultivation [Gesneriaceae]. Baileya **15:** 79–81. 1967.
214. The fern herbarium of André Michaux. Amer. Fern J. **57:** 166–182. 1967.
215. Two epiphytic Gesneriaceae of western Mexico. Baileya **15:** 119–123. 1968.
216. Enterosora integra *in* J. A. Steyermark, Flora del Auyan-tepui. Acta Bot. Venez **2:** 123–124. 1968.
217. The Peruvian Species of Besleria (Gesneriaceae). Contr. U. S. Nat. Herb. **38**(4): 125–151. 1968.
218. A proposal to amend Article 7 of the Code. Taxon **17:** 236. 1968.
219. Proposal for an addition to Article 26 of the Code. Taxon **17:** 236–237. 1968.
220. Proposed addition to the Guide to the Citation of Botanical Literature. Taxon **17:** 237. 1968.
221. The genera, subgenera, and sections of the Hymenophyllaceae. Contr. U. S. Nat. Herb. **38**(5): 153–214. 1968.
222. A typification of some subfamily, sectional, and subsectional names in the family Malpighiaceae. Taxon **17:** 314–324. 1968.
223. The correct name of a common tropical American Oleandra. Amer. Fern J. **58:** 105–107. 1968.
224. The fern collections in some European herbaria. Amer. Fern J. **58:** 158–168. 1968.
225. A new name for Columnea costaricensis Raymond. The Gloxinian **19:** 17. 1969.
226. The fern collections in some European herbaria, II. Amer. Fern J. **59:** 11–22. 1969.
227. A second species of Omiltemia. Baileya **16:** 78. 1969.
228. The fern collections in some European herbaria, III. Amer. Fern J. **59:** 48–55. 1969.
229. New combinations in Cyathea, Ctenitis, and Asplenium. Amer. Fern J. **59:** 65–67. 1969.
230. The fern collections in some European herbaria, IV. Amer. Fern J. **59:** 89–106. 1969.
231. A new weed introduction in New England, Atriplex sibirica. Rhodora **71:** 580–581. 1969.
232. The fern genus Gymnocarpium Newm. and its typification. Taxon **18:** 661–662. 1969.
233. The fern collections in some European herbaria, V. Amer. Fern J. **59:** 137–149. 1969 [1970].
234. A further note on the type of Platycerium alcicorne. Amer. Fern J. **60:** 7–12. 1970.
235. A new form of Microlepia speluncae. Amer. Fern J. **60:** 28–29. 1970.
236. Le nom exact d'un Pteris du Portugal et des Iles Atlantiques. Bull. Soc. Bot. France **116:** 247–248. 1970.
237. A reply to A. V. Hall on the names of subsidiary groups. Taxon **19:** 485. 1970.
238. The fern collections in some European herbaria, VI. Amer. Fern J. **60:** 49–61. 1970.
239. A peculiar species of Grammitis. Amer. Fern J. **60:** 65–67. 1970.
240. Proposal for the conservation of the generic name Drynaria (Bory) J. Smith (Filicineae). Taxon **19:** 647. 1970.
241. The lectotype of Polypodium leptophyllum L. Amer. Fern J. **60:** 101–103. 1970.
242. Taxonomic notes on Ferns, IV. Amer. Fern J. **60:** 103–106. 1970.
243. Pyrrosia princeps, a fern new to cultivation. Amer. Fern J. **60:** 118–119. 1970.
244. A commentary on some type specimens of ferns in the herbarium of K. B. Presl (review). Amer. Fern J. **60:** 119–123. 1970.
245. Some types and range extensions in Hybanthus (Violaceae). Phytologia **21:** 56–62. 1971.
246. The genus Columnea (Gesneriaceae) in Panama. Phytologia **21:** 165–195. 1971.
247. The proper disposition of Meniscium macrophyllum Kunze. Amer. Fern J. **61:** 17–20. 1971.
248. Niphidium longifolium, a necessary new combination. Amer. Fern J. **61:** 37–39. 1971. (with D. B. Lellinger)

249. Ferns and allies *in* I. L. Wiggins and D. M. Porter, Flora of the Galápagos Islands. pp. 61–176. 1971. (with I. L. Wiggins)
250. A Columnea species and an Episcia species [Gesneriaceae] new to science and cultivation. Baileya **18:** 6–12. 1971. (with M. Raymond)
251. The fern collections in some European herbaria, VII. Amer. Fern J. **61:** 59–75. 1971.
252. A wrongly localized species of Pyrrosia. Amer. Fern J. **61:** 94. 1971.
253. Supplementary notes on Grammitis in Ecuador. Phytologia **22:** 71–82. 1971.
254. Asplenium kamtchatkanum Gilbert, a dubious eastern Asiatic fern. Amer. Fern J. **61:** 140–141. 1971.
255. A reduction of Trichantha to Columnea (Gesneriaceae). Phytologia **22:** 223–224. 1971.
256. The genus Grammatosorus. Amer. Fern J. **61:** 145–148. 1971.
257. Notes on the ferns of Dominica and St. Vincent, II. Amer. Fern J. **61:** 161–165. 1971. (with D. B. Lellinger)
258. Studies in Dioscorea, II: An unusual new species from Mexico. Proc. Biol. Soc. Washington **84:** 445–448. 1972. (with B. G. Schubert)
259. Some overlooked combinations for eastern North American ferns. Amer. Fern J. **62:** 30. 1972.
260. Date of publication of Sodiro's "Cryptogamae Vasculares Quitenses." Amer. Fern J. **62:** 57–64. 1972.
261. Lectotypifications of some generic names of Gesneriaceae. Taxon **21:** 669–678. 1972. (with D. Denham)
262. Pteridophyta *in* J. A. Steyermark, The Flora of the Meseta del Cerro Jaua. Mem. N. Y. Bot. Gard. **23:** 845–846. 1972. (with D. B. Lellinger)
263. A new species of Besleria from Venezuela. Acta Bot. Venez. **6:** 95–97. 1972.
264. Lectotypification of Isoloma and Campanea (Gesn.). Taxon **22:** 317–318. 1973.
265. Studies of fern types, II. Contr. U. S. Nat. Herb. **38**(6): 215–281. 1973.
266. William Roxburgh, his life, collections, and fern types. Contr. U. S. Nat. Herb. **38**(7). (in press)

A New Species of Microgramma from Argentina

ELÍAS R. DE LA SOTA*

The systematic revision of Argentine Polypodiaceae (*s. str.*) and Grammitidaceae that was published some years ago (de la Sota, 1960) included in the genus *Microgramma* three species: *M. lindbergii* (Mett.) de la Sota, *M. squamulosa* (Kaulf.) de la Sota, and *M. vacciniifolia* (Langsd. & Fisch.) Copel.

Investigations have continued concerning the naturalness of the genus *Microgramma,* its delimitation, and its relationships with other groups of neotropical Polypodiaceae, especially with *Pleopeltis* and certain other simple-bladed species of *Polypodium*. All this will be discussed in a future publication, giving various morphological details for as many species as possible of this problematical genus.

De la Sota (1960, pp. 69–71) mentioned the heterogeneity of *M. vacciniifolia* specimens, especially those found in the forests along the banks of the Río de La Plata and its minor tributaries. Between those specimens and the ones from the remainder of the species' area (Brazil, Paraguay, eastern Bolivia, and northeastern Argentina) there are differences in rhizome scale morphology and in frond size, texture, dimorphism, and venation.

A recent, careful analysis of the specimens growing in the forest communities along the Río de La Plata, or on cultivated trees in its vicinity, has led to the conclusion that these specimens are a new species directly related to *M. squamulosa* and *M. vacciniifolia*. This newly recognized entity is fertile and is entirely intermediate in morphology between the aforementioned species. This fact, coupled with its geographic distribution and with a significant difference in stomate and spore size, are arguments in favor of a hybrid origin for this taxon, followed presumably by chromosome doubling. The characters which distinguish the hybrid and its putative parents are as follows:

MICROGRAMMA SQUAMULOSA.—Rhizome scale margins markedly ciliate; sterile fronds 60–135 mm long, 13–22 mm wide, 4–8 × longer than wide; fertile fronds 50–150 mm long, 5–13 mm wide, 8–16 × longer than wide; foliar dimorphism weak; sterile laminae with costal and marginal areoles, the larger ones with free and anastomosing veinlets; fertile laminae with costal and marginal areoles; receptacles large, usually served by 2 connivent (simple or ramified) veinlets, the receptacular vascular reticulum of short, scalariform tracheids, more or less complete; paraphyses very branched, with the branch cells short.

MICROGRAMMA VACCINIIFOLIA.—Rhizome scale margins dentate; sterile fronds 11–50 mm long, 7–15 mm wide, 1–5 × longer than wide; fertile fronds 25–80 mm long, 2–7 mm wide, 5–32 × longer than wide; foliar dimorphism extreme; sterile laminae lacking costal areoles, the larger ones with a single, free, simple included veinlet, this rarely anastomosing and branched; marginal areoles present or absent; fertile laminae with neither costal nor marginal areoles; receptacles small, served by a single veinlet, with no receptacular vascular reticulum of short, scalariform tracheids visible; paraphyses slightly branched, with the branch cells long.

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MICROGRAMMA MORTONIANA.—Rhizome scale margins sparingly ciliate; sterile fronds 25–95 mm long, 10–20 mm wide, 2–6 × longer than wide; fertile fronds 60–125 mm long, 3.5–8 mm wide, 8–24 × longer than wide; foliar dimorphism intermediate; sterile laminae with the costal areoles complete or incomplete, marginal areoles present, the larger areoles generally with more than 1 included veinlet, this branched and partially anastomosing; fertile laminae with or without costal and marginal areoles; receptacles of medium size, served by 1 veinlet or more, commonly situated above the veinlet which borders a costal areole, the receptacular vascular system a compact mass or simple reticulum of short, scalariform tracheids; paraphyses slightly branched, with the branch cells medium to long.

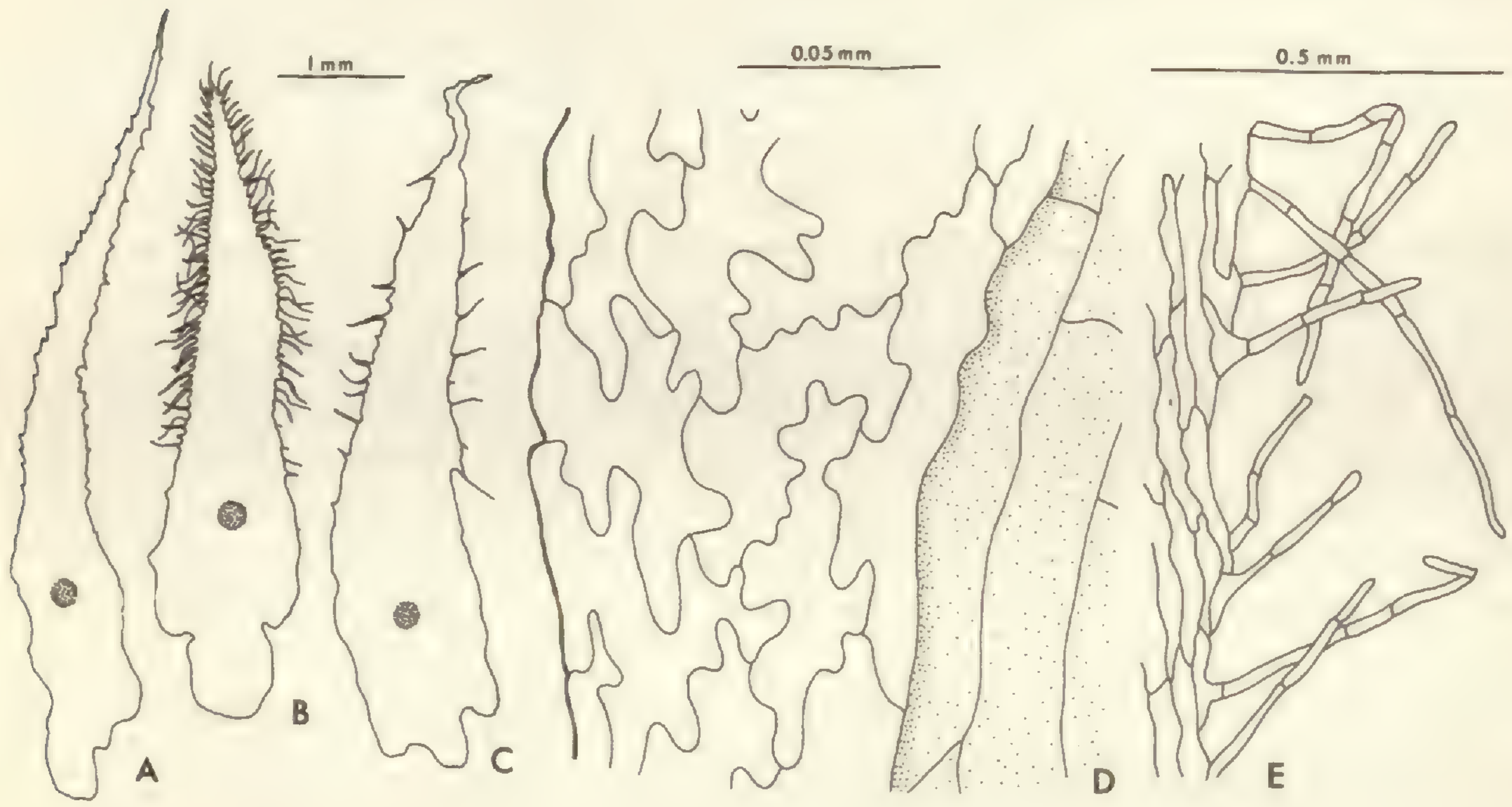

Fig. 1. Rhizome scales of *Microgramma*. Fig. 1A. *M. vacciniifolia*. Fig. 1B. *M. squamulosa*. Fig. 1C. *M. mortoniana*. Fig. 1D. Same, margin near scale base. Fig. 1E. Same, margin near scale apex.

The distributions of *M. squamulosa* and *M. vacciniifolia* overlap in part (Brazil, Paraguay, and northeastern Argentina). *Microgramma squamulosa* is basically a montane element, whereas *M. vacciniifolia* generally grows at a low altitude and almost always as an epiphyte in the gallery forests; for this reason it is considered to be a fluvial migrant (de la Sota, 1967). Despite these differing ecological preferences, it is highly likely that these species have been in proximity in northeastern Argentina and Brazil, inasmuch as *M. squamulosa* has a broad altitudinal range and can be found in localities just a few meters above sea level.

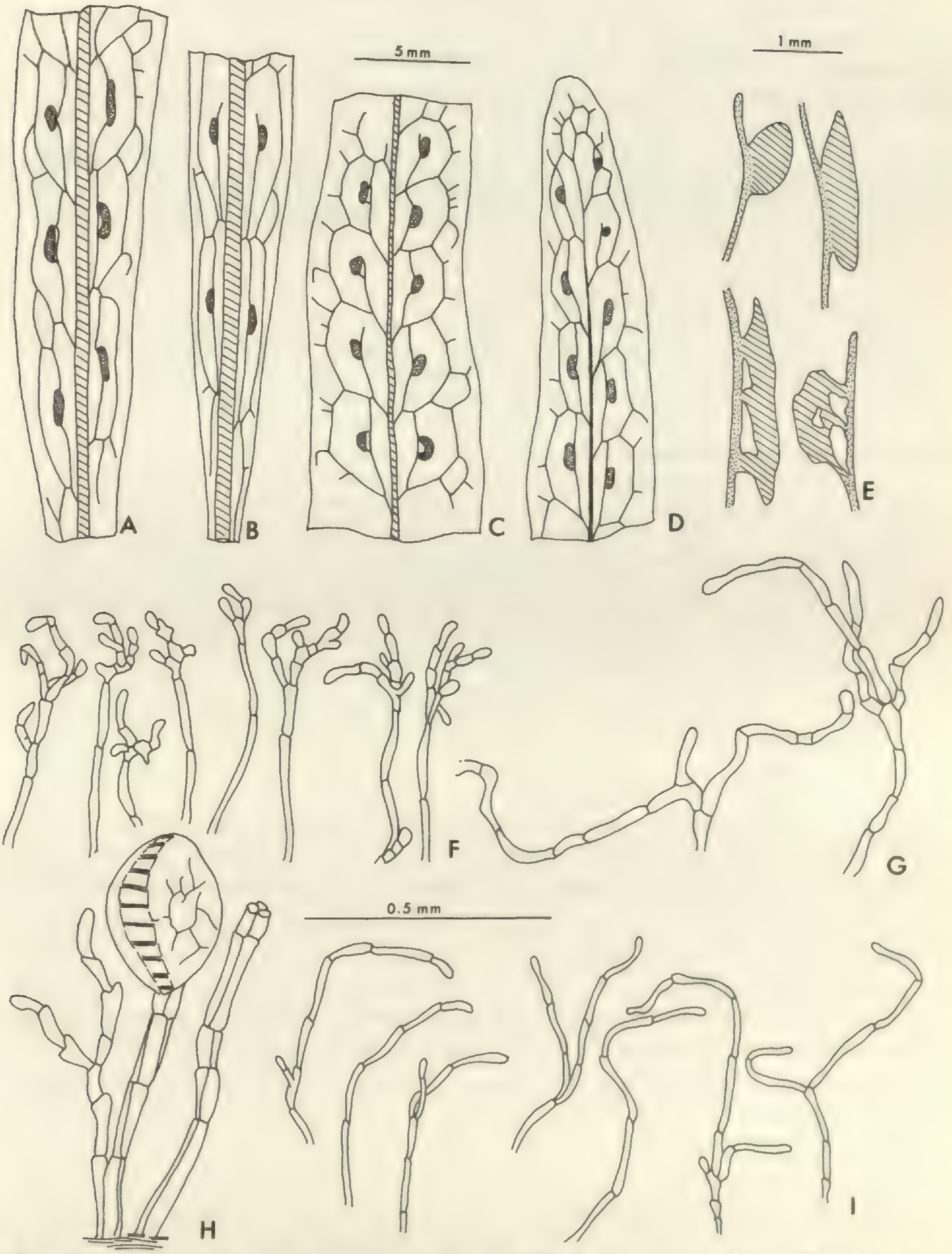

Fig. 2A–E. Vasculature of the fertile lamina of *Microgramma mortoniana*. Figs. 2A, B. Basal portion. Fig. 2C. Medial portion. Fig. 2D. Apical portion. Fig. 2E. Receptacular vasculature of *M. mortoniana* (t = scalariform tracheids, v = vein). Fig. 2F–I. Soral paraphyses of *Microgramma*. Fig. 2F. *M. squamulosa*. Fig. 2G. *M. mortoniana*, the latter with a young sporangium. Fig. 2I. *M. vacciniifolia*.

The mechanism of polyploidy (chromosome doubling) explains the hybrid's fertility (which was proved by sowing and germinating the spores). Additional data support this well, like the vigor of the plants and the dimensions of the stomates and spores, which are larger than those of the presumed parents.

As one can see from the comparative analysis, numerous characters of the hybrid are intermediate between the parents. These characters, the geographic data, and the vigor of the plants all support the fact of hybrid origin for the species, which is named in honor of the late, distinguished North American pteridologist C. V. Morton:

Microgramma mortoniana de la Sota, sp. nov.

Herba epiphytica; rhizomate late repenti, ramoso, subcylindrico, 3–5 mm crasso, squamulis dense imbricatis, persistentibus, appressis, castaneis, ovato-lanceolatis, base irregulariter undulatis, apice attenuatis, margine parum ciliatis, 3–5 mm longis, 0.7–1 mm latis, centro castaneis, areis marginalibus, basalibus et apicalibus albidis; frondibus distantibus, dimorphis, coriaceis; petiolis brevibus, usque ad 20–25 mm longis, squamosis vel glabrescentibus; frondibus sterilibus ellipticis vel elliptico-lanceolatis, apice rotundatis, base attenuatis, 25–95 mm longis, 10–20 mm latis, supra glabris, infra glabrescentibus vel supra et prope costam squamosis, squamulis caducis, parvis, albidis, ovatis, acuminatis, ciliatis, venis secundariis immersis, anastomosantibus, areolas costales et marginales formantibus, areolis magnis venulas ramosas et anastomosantes includentibus; frondibus fertilibus linearibus vel lineari-lanceolatis, apice obtusis vel attenuatis, base attenuatis, margine plerumque undulatis, 60–125 mm longis, 3.5–8 mm latis, venis secundariis immersis et anastomosantibus, areolas costales frequenter formantibus, venulis marginalibus raro areolatis plerumque liberis, areolis magnis venulas fertiles singulas, liberas vel anastomosantes includentibus; soris rotundis vel ellipticis et obliquiis, parum impressis, 1.5–3 mm diametro, supra venulas dorsalibus et subterminalibus; sporangiis cum paraphysibus numerosis intermixtis; paraphysibus filamentosis, ramosis, cellulis ramorum brevibus vel elongatis; sporis reniformibus, flavis, 86(78–90)μ longis.

TYPE: Delta of the Río Chaná, Prov. Buenos Aires, Argentina, January 1914, *A. C. Scala 16* (LP).

ADDITIONAL SPECIMENS EXAMINED:

ARGENTINA: Buenos Aires: La Plata, *Rodrigo 2227, 2054, Dawson 324, 1007* (all LP), *Abbiatti* (LP 561199); Isla Santiago, *Alboff* (LP 18996), *Cabrera 1506* (LP); Delta, Río Chaná, *Scala 13, 14* (both LP). **Misiones:** San José de Pindapoy, *Bridarolli 2662* (LP).

This species is very frequent in the riverine forests of Punta Lara (Prov. Buenos Aires), in the Delta of the Río Paraná, and in trees along the streets, plazas, and avenues in the vicinity. Occasionally it is encountered in the Province of Misiones, and very probably it will be found also in southern Brazil, Paraguay, and in other localities in northeastern Argentina.

LITERATURE CITED

SOTA, E. R. de la 1960. Polypodiaceae y Grammitidaceae Argentinas. Opera Lilloana **5:** 1–229, *f. 1–38.*

————. 1967. Composición, origen y vinculaciones de la flora pteridológica de las Sierras de Buenos Aires. Bol. Soc. Argentina Bot. **11:** 102–128, *f. 1–13.*

Thelypteris in Northeastern North America[1]

ALICE TRYON and ROLLA TRYON*

The diversity and broad scope of the publications of Conrad Morton will strongly influence floristic, revisionary and nomenclatural studies of ferns. His series of papers on *Thelypteris* particularly show his many interests and accomplishments. The taxonomic work in the subgenus *Meniscium* (1938) is one of several done in collaboration with W. R. Maxon, his predecessor in Pteridology at the Smithsonian Institution. The paper on the classification of *Thelypteris* (1963b) shows his concern with the taxonomy of the whole group, while that on West Indian *Thelypteris* (1963a) shows his interest in ferns of the Caribbean area, and the one on California *Thelypteris* (1958) his attention to the ferns of his native state. His studies of fern types (1967a) and of the Michaux Herbarium (1967b) are important sources of information dealing with nomenclature and typification. This selection of his publications, over a period of thirty years, provides invaluable information on *Thelypteris*. We draw upon these in our study, particularly in relation to the nomenclature of *Thelypteris palustris*.

The three species of *Thelypteris*—the Marsh Fern, *T. palustris,* the New York Fern, *T. noveboracensis,* and the Massachusetts Fern, *T. simulata*—have been found growing together at many different sites during our field studies in New England, over the past ten years. *Thelypteris palustris* grows in the wettest places that are usually inundated during part of the year. *Thelypteris noveboracensis* grows in drier sites, and *T. simulata* is usually in deep shade in wet, peaty soils, often in association with *Sphagnum*. Particular search has been made for plants intermediate between the species, but none have been found. Study of the materials of the three species in the Gray Herbarium, the Herbarium of the New England Botanical Club, the Pringle Herbarium, and the United States National Museum also yielded no specimens considered to be intermediates. The three species are distinctive and there is no evidence of hybridization between them.

The distribution of the three species in eastern North America is shown in *Fig. 1*. *Thelypteris palustris* is the most wide-ranging species, *T. noveboracensis* does not extend as far south or west, and *T. simulata* has a rather restricted range. It has a notable disjunct station in the Driftless Area of Wisconsin (Hartley, 1965). Each of the species has close relations to the west. The same variety of *T. palustris* occurs in eastern Asia, *T. noveboracensis* is related to *T. nevadensis* of western North America and to *T. beddomei* and *T. nipponica* of eastern Asia, and *T. simulata* has close affinities with *T. glanduligera* and *T. japonica* of east-

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[1] The new cytological records of *Thelypteris palustris* from Japan are the work of Dr. Kunio Mitui, Nippon Dental College, Niigata City, and Dr. Siro Kurita, Chiba University, Chiba, who reported on the collections of M. Nishida. We are most appreciative of their cooperation in providing the information and illustrations. We are much indebted to Dr. R. K. Godfrey for collections of *T. palustris* from Florida, to Dr. T. G. Hartley and Dr. H. H. Iltis for collections from the Driftless Area of Wisconsin, and to Ruth Carpenter for material of the crested Marsh Fern. Stanley J. Smith has supplied distribution records of *T. simulata* from New York and has guided us to fine bogs near Taborton, New York.

ern Asia. These geographic relations are presented in *Table 2*, along with those of other eastern North American species that have disjunct relations in eastern Asia.

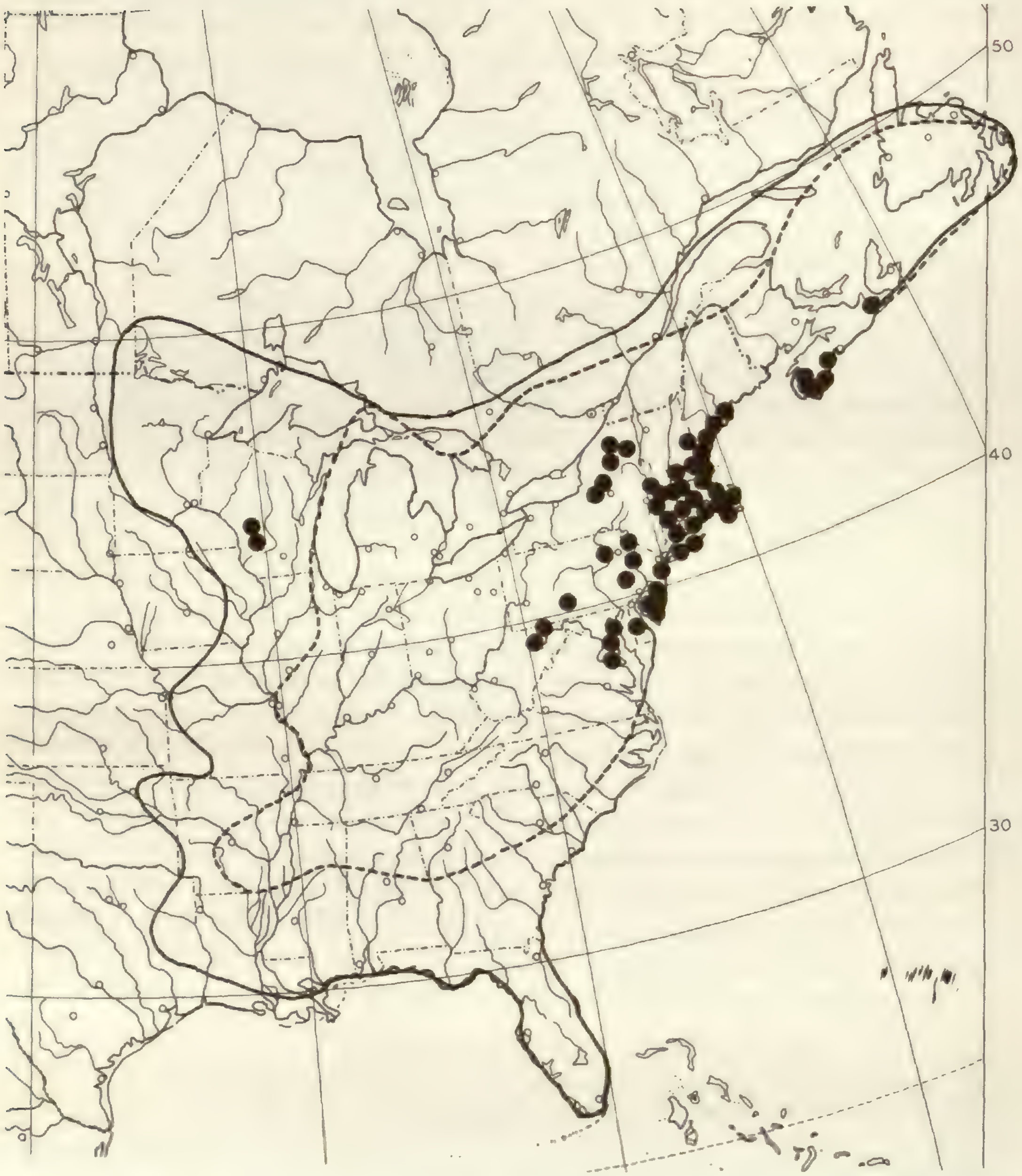


Fig. 1. Distribution of *Thelypteris simulata* (dots), *T. noveboracensis* (dash line), and *T. palustris* (solid line) in North America.

NOMENCLATURE AND TYPIFICATION

Thelypteris palustris is adopted for the Marsh Fern, although we recognize that a nomenclatural change is probably needed. The correct name will ultimately depend on a thorough systematic analysis of the species over its entire range. Fernald (1929) treated the Marsh Fern as a single species with four geographic varieties, and some of these have been recognized as subspecies. Recently Holub (1972) accepted two species: *T. confluens,* ranging from Africa to New Zealand, and *T. thelypterioides,* with one subspecies in Europe and another in eastern Asia and eastern North America. Variation in the spores, indusium, and indument of the taxa (A. Tryon, 1971) demonstrates that the relationship of var. *pubescens* and var. *haleana* needs to be reassessed and that the variation in the other varieties requires further study.

There are also problems in typification. The name *Thelypteris thelypterioides,* recently used by Holub, is based on *Nephrodium thelypterioides* Michaux. However, it is quite possible that Michaux's name is properly applied to *T. noveboracensis* rather than to *T. palustris*. The description of *Nephrodium thelypterioides* by Michaux (1803) includes characters, such as the pubescent costa and small sori not confluent at maturity, that are consistent with those of *T. noveboracensis*. It was stated by D. C. Eaton (1870) that the specimen in the Michaux Herbarium at Paris, "Polypodium Thelypterioides—montibus Allegeni a Canada; Hab. in Canada et ad Carolinanum; Lac Champlain" (=*Nephrodium thelypterioides*) was *Aspidium Thelypteris* (=*Thelypteris palustris*). However, in his "Ferns of North America," Eaton (1879) cited *Nephrodium thelypterioides* Michaux as a synonym of *Aspidium noveboracense*. In this he was following earlier authors, such as Asa Gray (1848). The specimen was considered by Morton (1967b) to be the holotype of Michaux's name. However, Michaux specimens were sometimes distributed to other herbaria, for example, those of Jussieu and Richard (both now at Paris) and of Delessert (now at Geneva). The holotypes of Michaux's names in some cases are not in his own herbarium; for example, that of *Asplenium thelypterioides* Michx. is (according to a marginal note by A. Gray in Michaux's Flora) in the Richard Herbarium, and that of *Blechnum serrulatum* Michx. is, according to Morton (1967b), in the Jussieu Herbarium. The typification of the name *Nephrodium thelypterioides* should be established with certainty before it is applied to a particular species.

Thelypteris simulata was first recognized by Raynal Dodge, and Davenport (1894) described it a few years later. Although it had long been overlooked, it was noted as locally common in many places soon after Davenport's publication. Davenport naturally compared it with the two closest species of the region, the Marsh Fern and the New York Fern. He emphasized that it was intermediate to them and this concept has persisted for many years. In the report of chromosome numbers for these species, Wagner (1963) interprets the count of $n=64$ for *T. simulata* in terms of an alloploid origin from *T. palustris* and *T. noveboracensis*. However, the Massachusetts Fern is quite distinctive and, as mentioned above, its relations are with species of eastern Asia.

A lectotype for *Aspidium simulatum* was selected by Rolla Tryon in 1947, but not published, based on comparisons of the collections in the Davenport Herbarium. The specimen is "*Aspidium simulatum* Davenport, Blue Hills Reservation, September 1894, from Geo. E. Davenport." It is part of the Davenport Herbarium of North American Ferns presented to the Massachusetts Horticultural Society and later deposited in the Gray Herbarium. The original publication of the species has the additional data: "Quincy, Mass. leg. Davenport." The specimen agrees with the principal illustration of the species published by Davenport (1896, *Fig. 69*). The only other specimen that might possibly be taken as the lectotype is from Indian Point, Georgetown, Maine. This was considered to be a sun-form and a small drawing of it was included in *Fig. 69*.

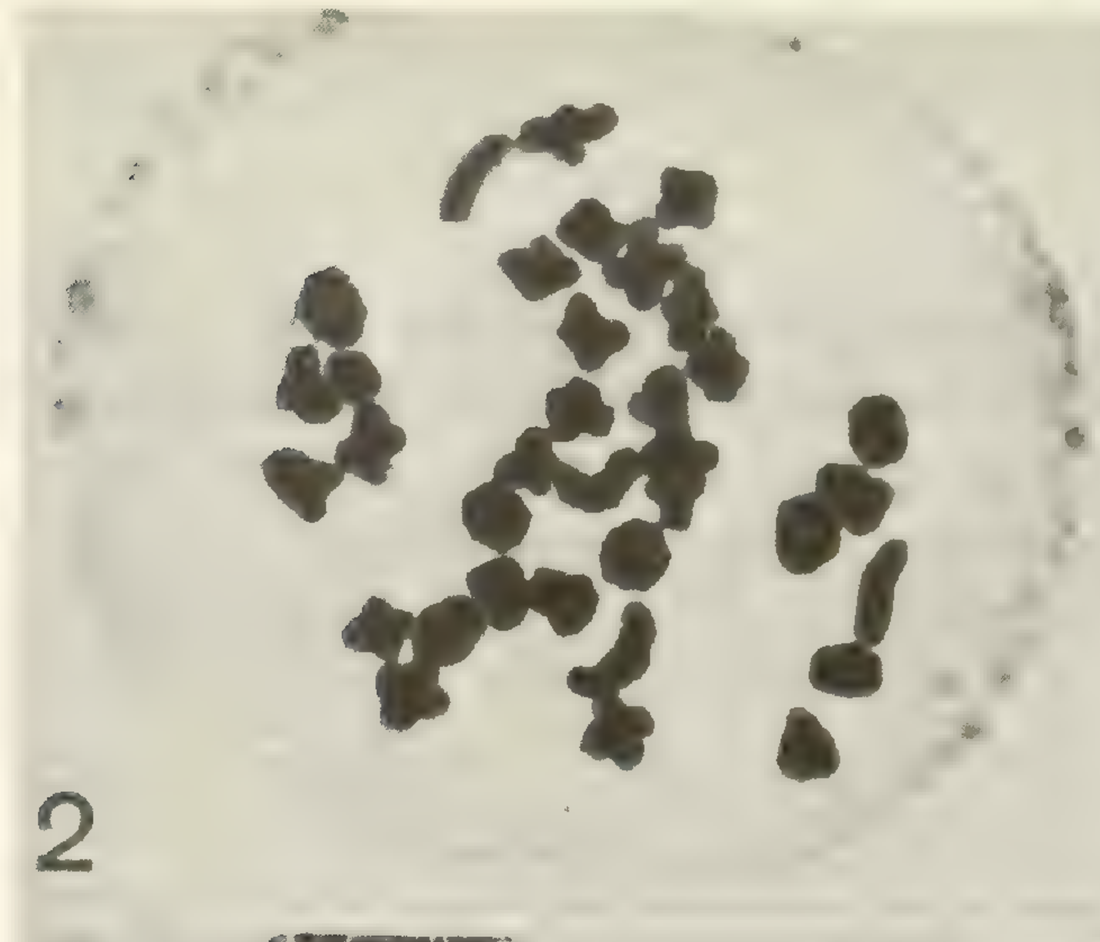
TABLE 1. CHROMOSOME NUMBERS IN THELYPTERIS.

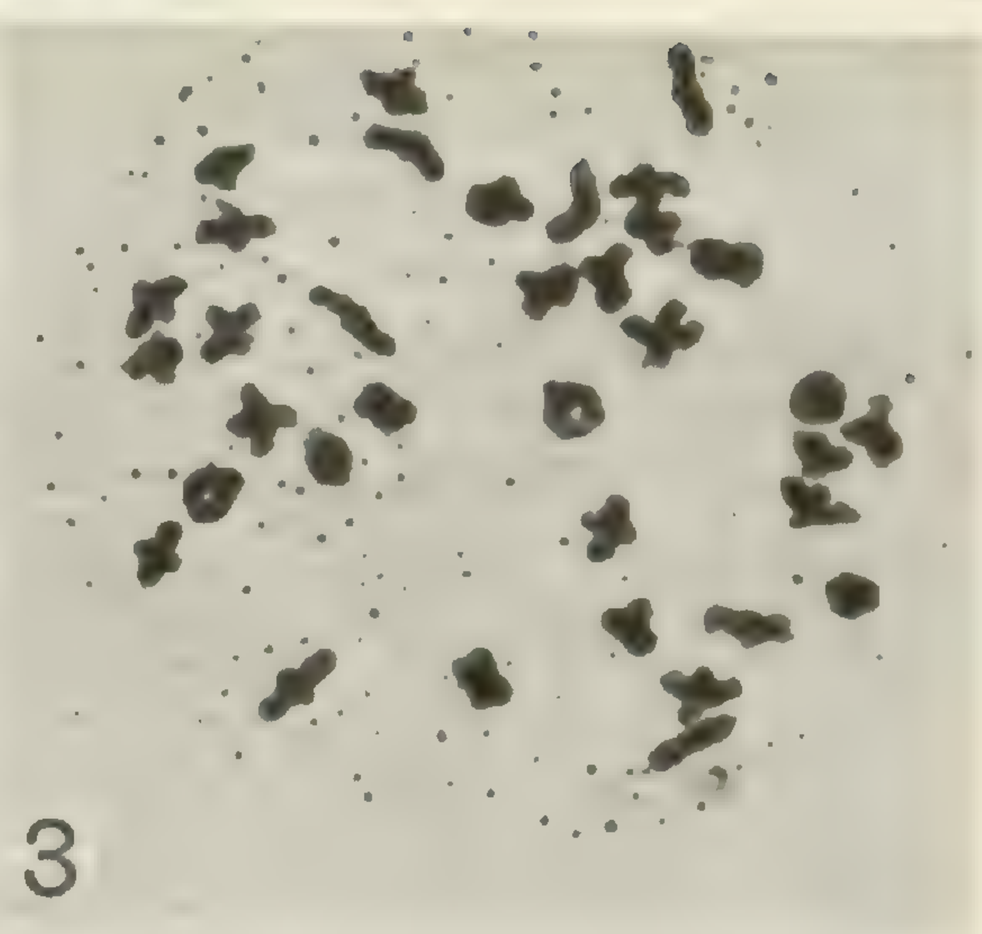
	Voucher or Reference	*Locality*	*Figure*
		Thelypteris palustris	
$n =$ 35	A. Tryon 70-18 (GH)	USA: Mass., Lexington	
35	A. Tryon 70-4 (GH)	USA: Mass., Lincoln	
35	A. Tryon 69-1 (GH)	USA: Mass., Blue Hills	
35[1]	A. Tryon 71-25 (GH)	USA: Mass., Sudbury	
35	A. Tryon 70-11 (GH)	USA: N. Y., Taborton	
35	R. Godfrey 71200 (GH)	USA: Fla., Dog Island	2
35	R. Hartley in 1970 (GH)	USA: Wis., Jackson Co.	3
35	W. H. Wagner (1955)	USA: Mich., Green Lake	
35	J. C. Oliver (1969)	USA: Ind., Porter Co.	
35	D. M. Britton (1953)	Canada: Ontario	
35	I. Manton (1950)	England	
35	V. Sorsa (1958)	Finland: Helsinki	
35	M. Nishida 720113	Japan: Chiba Pref., Inage	8
35	K. Mitui MCN 763	Japan: Niigata Pref., Imakawa	9
		Thelypteris noveboracensis	
27	A. Tryon 70-24 (GH)	USA: Mass., Lexington	4
27	A. Tryon 69-5 (GH)	USA: Mass., Lincoln	
27	A. Tryon 69-2 (GH)	USA: Mass., Blue Hills	
27	A. Tryon 70-15 (GH)	USA: Maine, Small Point	
27	A. Tryon 70-12 (GH)	USA: N. Y., Taborton	
27	W. H. Wagner (1955)	USA: Mich.	
27	J. C. Oliver (1969)	USA: Ind., Delaware Co.	
27	D. M. Britton (1964)	Canada: Ontario	
		Thelypteris simulata	
64	A. Tryon 69-3 (GH)	USA: Mass., Blue Hills	
64	A. Tryon 69-6 (GH)	USA: Mass., Lincoln	
64	A. Tryon 70-17 (GH)	USA: Mass., Osterville	5
64	A. Tryon 65-14 (GH)	USA: Maine, Old Orchard	6
64	A. Tryon 70-10 (GH)	USA: N. Y., Taborton	
64	W. H. Wagner (1963)	USA: Maryland	
$2n = 128$	H. Iltis in 1972 (GH)	USA: Wis., Jackson Co.	7

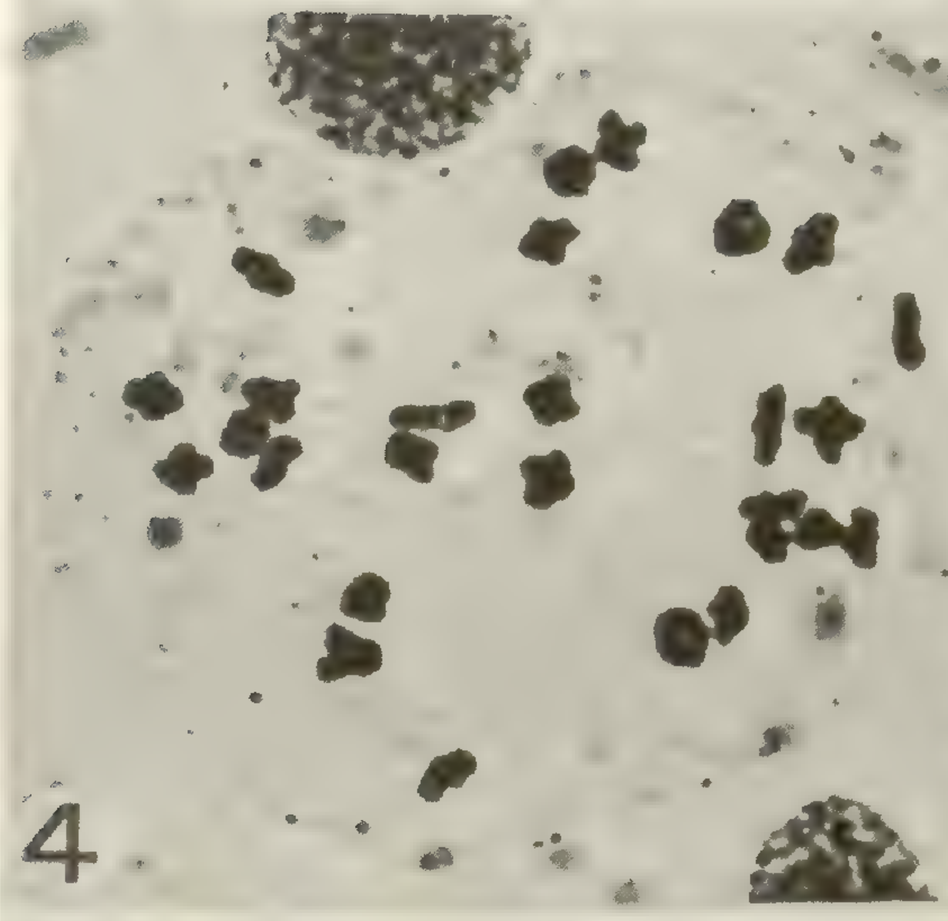
[1] *Thelypteris palustris* f. *pufferae*.

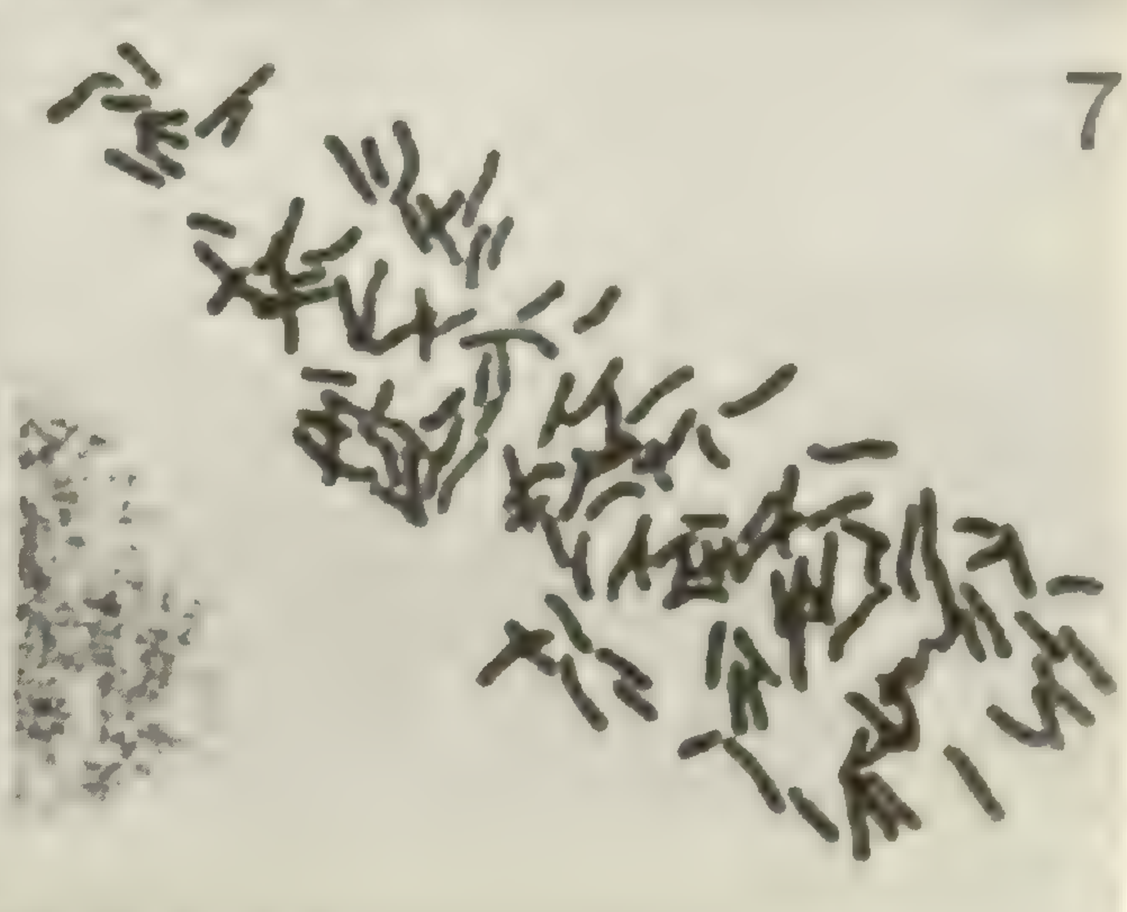
CYTOLOGY

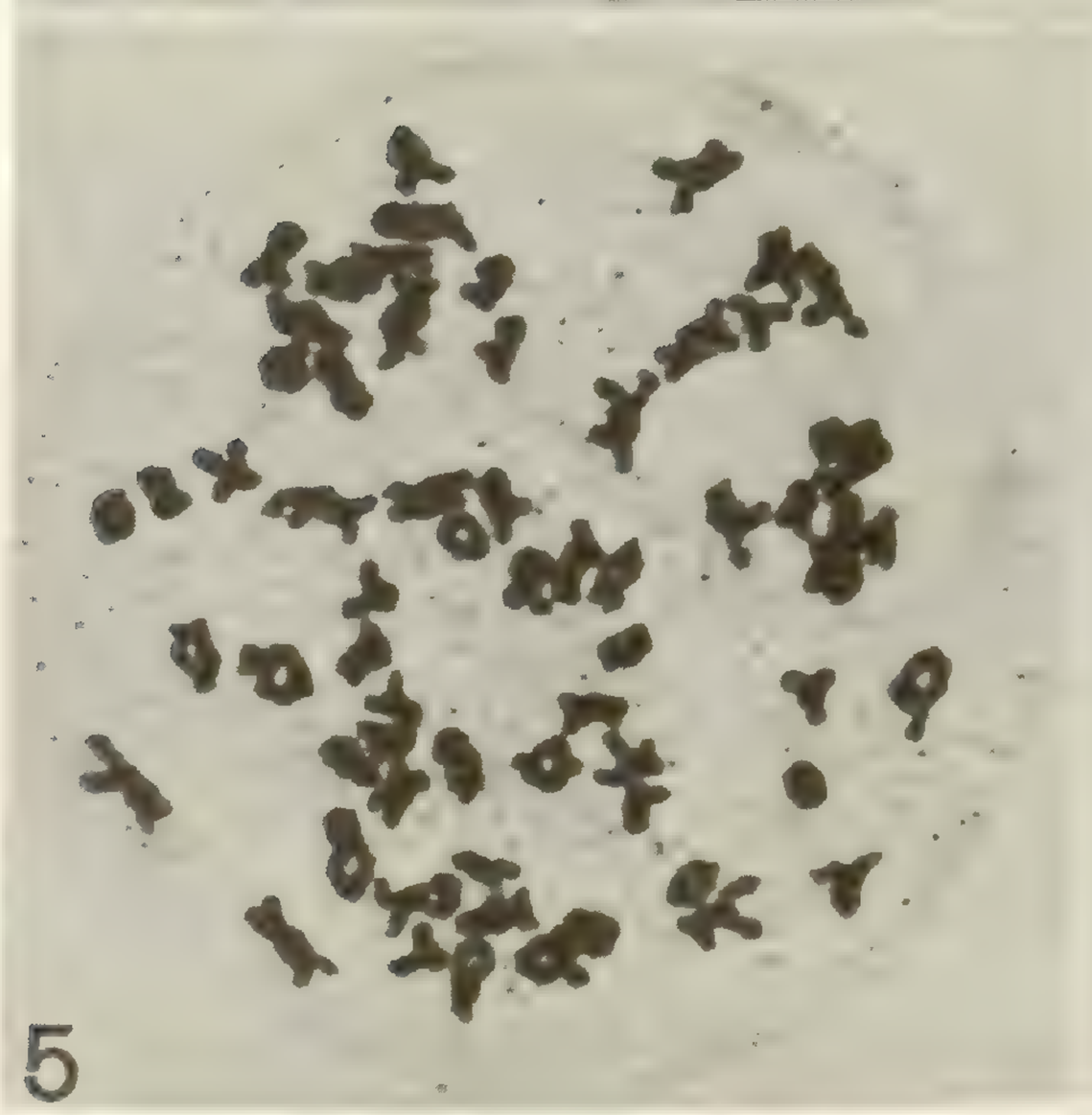
Chromosome numbers from this study and previous reports of the species are summarized in *Table 1*. The new chromosome records of American plants re-

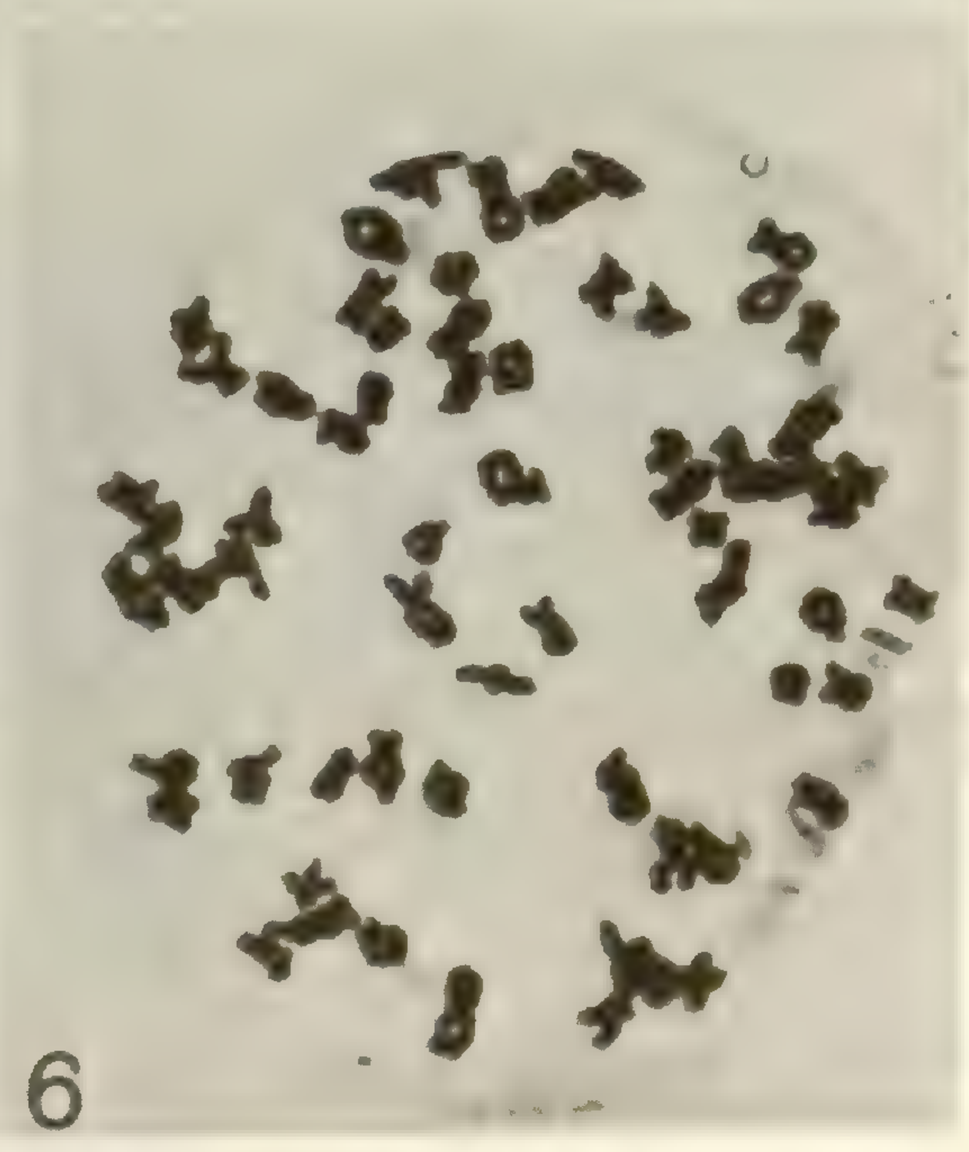












Chromosomes of *Thelypteris*, × 1000. Figs. 2, 3. *T. palustris*, meiotic with 35 bivalents. Fig. 2. *R. Godfrey*, Fla. Fig. 3. *R. Hartley*, Wis. Fig. 4. *T. noveboracensis*, meiotic with 27 bivalents, *A. Tryon 70-24*, Mass. Figs. 5–7. *T. simulata*. Figs. 5, 6. Meiotic with 64 bivalents. Fig. 5. *A. Tryon 70-17*, Mass. Fig. 6. *A. Tryon 65-14*, Maine. Fig. 7. Mitotic chromosomes, $2n=128$, H. Iltis, Wis.

ported here are documented by permanent slides and photographs; voucher specimens are deposited in the Gray Herbarium. The photographs in *Figs. 2–7* are a selection of those taken from several populations. The collections studied were field specimens or transplants of these to an experimental garden in Lexington, Massachusetts. The meiotic numbers are reported from fixations of young sporangia in 3:1 ethanol:acetic acid. The mitotic record is from root tips of a specimen grown in a growth chamber kept at a temperature of 72° F and a 16 hour day. The root tips were treated with snail cytase following the procedure of Chambers (1955).

Thelypteris palustris is reported as $n=35$ from Ontario, Michigan, Indiana, England, and Finland. The collections examined in this study from New York, Florida (*Fig. 2*), Wisconsin (*Fig. 3*), and several localities in Massachusetts uniformly have 35 bivalents at meiosis. A specimen with crested leaves, the "forma *pufferae,*" also had 35 bivalents. This count was made from a garden plant that originated from the type locality in Sudbury, Massachusetts. There are several reports of *Thelypteris palustris* from Japan with $n=36$ (Mitui, 1968; Hirabayashi, 1969). Collections have been recently examined from several localities in Japan that consistently have 35 bivalents at meiosis. The meiotic cell in *Fig. 8* from Inaga, Chiba Prefecture, is one of five specimens examined by Dr. Siro Kurita. The record from Imakawa, *Fig. 9*, is one of three collections from Niigata Prefecture studied by Dr. Kunio Mitui. These new records document the occurrence of plants in Japan with the same chromosome number as those in England, Europe, and America.

Thelypteris noveboracensis has been reported from Michigan, Indiana, and Ontario with a chromosome number of $n=27$. In the reports from Ontario by Britton (1953, 1964), he remarks on the small size and difficulty in spreading the chromosomes. The collections we studied from Maine, New York, and Massachusetts (*Fig. 4*) uniformly had 27 bivalents at meiosis. The fixations, especially of the native plants from Lexington, Massachusetts, yielded good squash preparations with relative ease. Populations of *T. noveboracensis,* from a large geographic sampling of the species in eastern North America, uniformly have 27 bivalents at meiosis. This represents the lowest chromosome number reported for the genus, and is the same as in *T. nevadensis* from western North America.

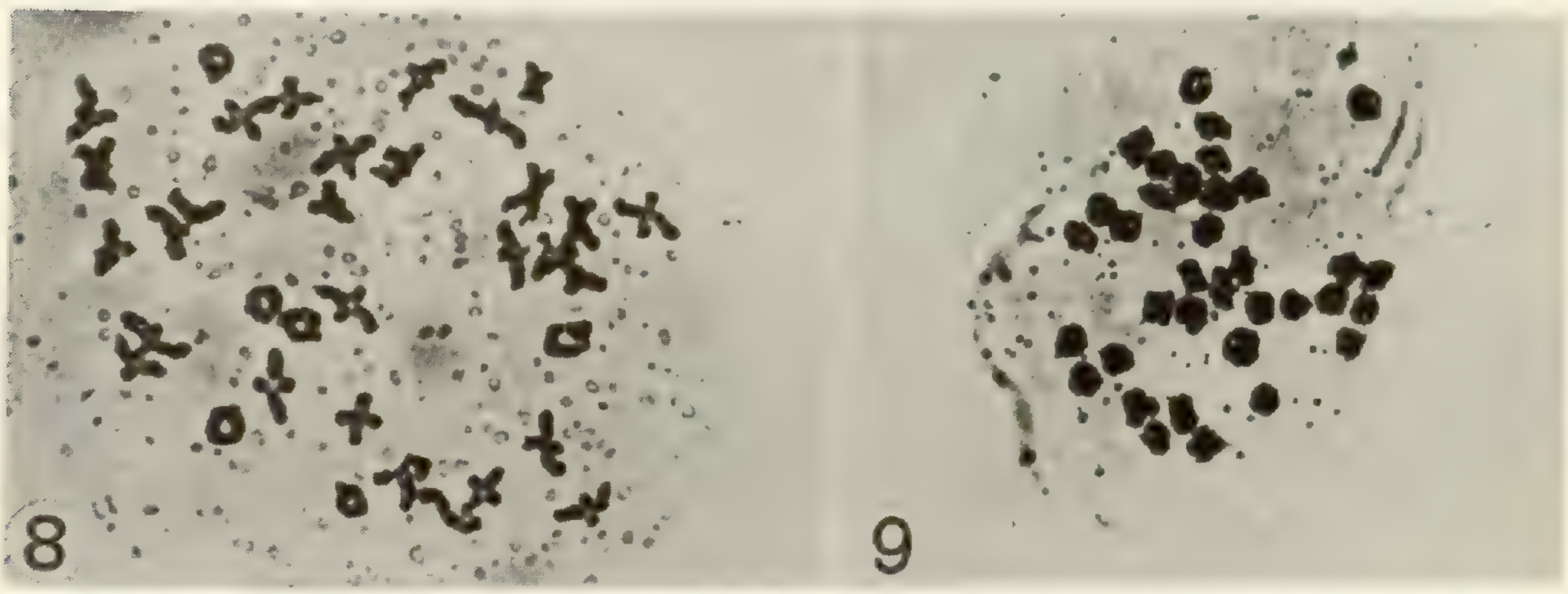
Thelypteris simulata has been reported from Maryland, without documentation, as $n=64$. Populations from Maine (*Fig. 6*), New York, and several localities in Massachusetts (*Fig. 5*) sampled in this study have 64 bivalents at meiosis. The mitotic cells from root tips of a collection from Jackson County, in the Driftless Area of Wisconsin (*Fig. 7*), have 128 chromosomes. Marked differences in the size and structure of these mitotic chromosomes show diagnostic characteristics useful for genome analyses of populations.

There are perhaps 800 species of *Thelypteris,* and the largest proportion of these are concentrated in southeastern Asia and Malaysia. The chromosome numbers of the neotropical species have been reviewed by A. R. Smith (1971). About one-eighth of the total has been cytologically sampled, mostly on a very limited geographic basis. Their chromosome numbers range from 27 to 136.

The disparate chromosome numbers, 27, 35, and 64, in the three species of eastern North America indicate that the species represent discrete cytological entities. The record of 64 bivalents in *Thelypteris simulata,* representing two more bivalents than the sum of the other two species, suggests that the species has not originated as a hybrid of *T. palustris* and *T. noveboracensis*.

SPORES

The scanning electron microscope studies of the spores were largely done with an AMR instrument, model 900, and the specimens were prepared as described earlier (A. Tryon, 1971). Those of *Thelypteris noveboracensis* photographed at the University of Illinois at Chicago Circle were not undercoated with carbon.



Meiotic chromosomes of *Thelypteris palustris* from Japan with 35 bivalents, × 1000. Fig. 8. *M. Nishida,* Chiba (from S. Kurita). Fig. 9. *K. Mitui,* Niigata (from K. Mitui).

A survey of the spores of *Thelypteris palustris* from several geographic areas has shown exceptional variation in the form of perine (A. Tryon, 1971). The reticulate type of perine in the specimens from Europe and the echinate forms in the spores from Kashmir, Tanganyika, and New Zealand are strikingly different than those with verrucate perine in eastern North America (*Figs. 10, 11*). Spores of populations examined from the southern and western portions of the range in North America show variation in the perine surface. These often have more irregularly projecting ridges or papillae and are similar to the form of perine in spores from Japan.

Thelypteris noveboracensis has spores (*Figs. 12, 13*) with a strongly reticulate perine with the ridges appressed to the spore surface and also projecting as irregularly perforate structures. The perine resembles that in spores of *Thelypteris nipponica* from Japan (*Fig. 16*), although in these the perine ridges are more continuous and prominent with somewhat larger areolae. The details are especially evident at higher magnification (*Fig. 17*).

The photograph of the spore of *Thelypteris simulata* (*Fig. 14*) shows the commissural ridge especially well. This ridge extends most of the length of the spore and is visible slightly above the central area. The prominent perine ridges

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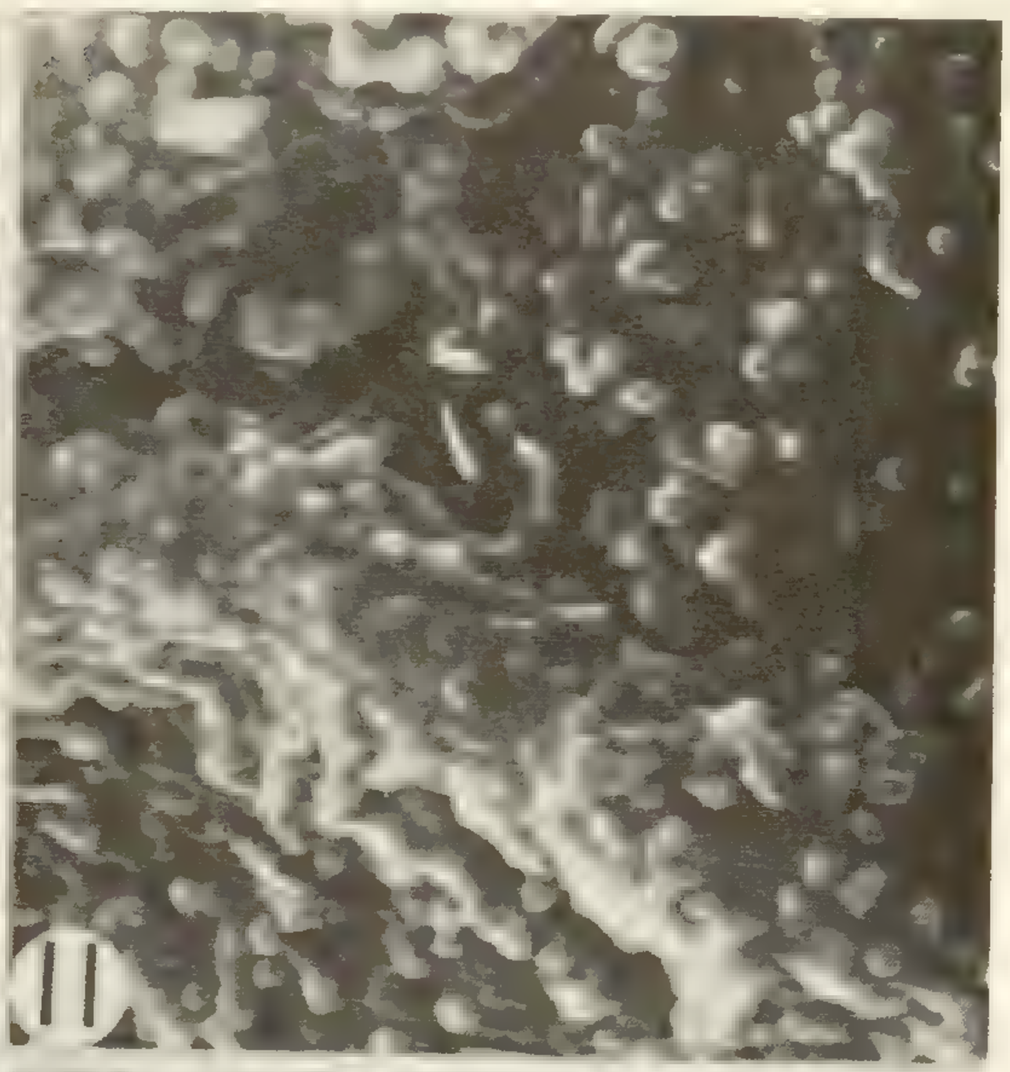
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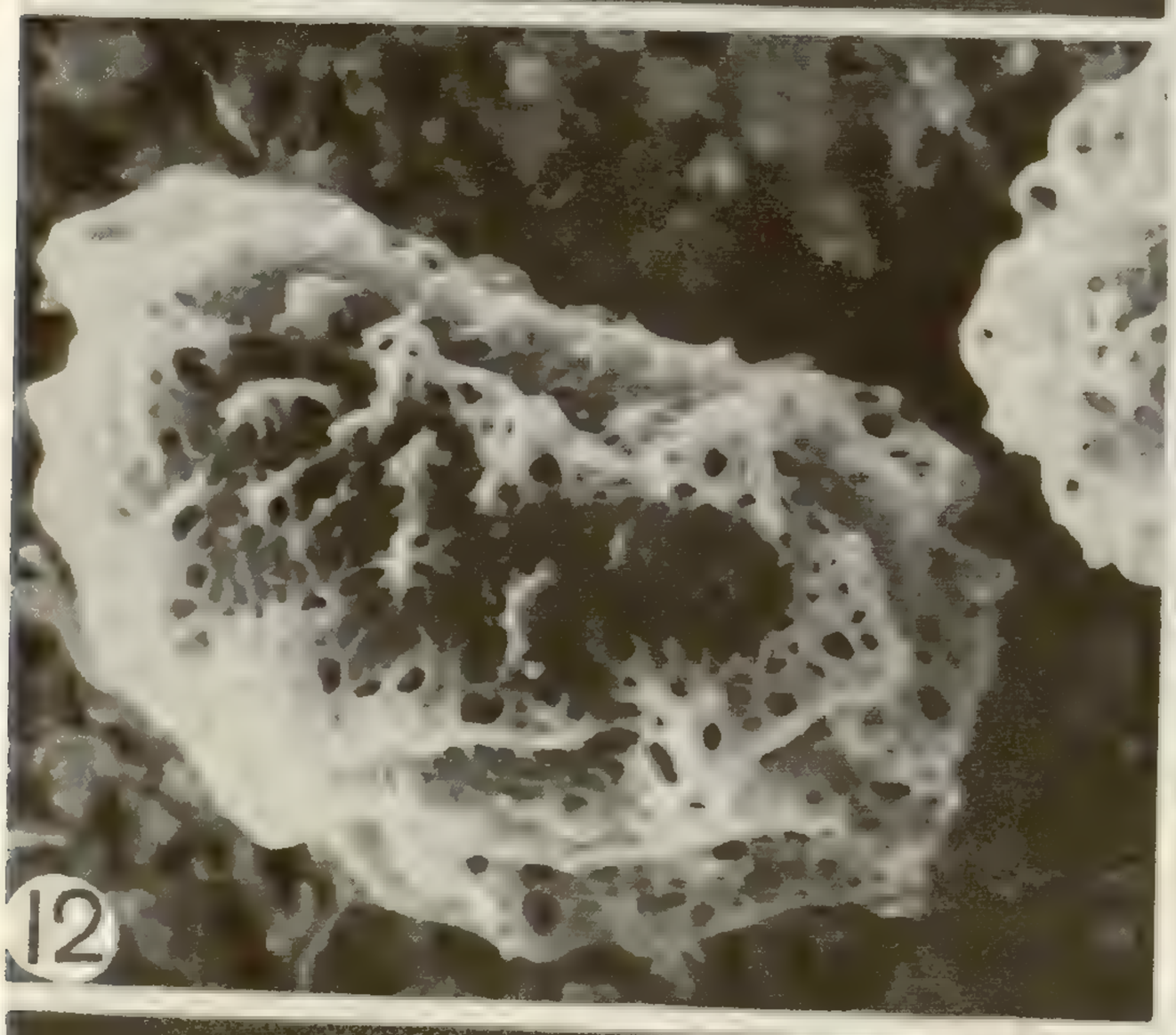
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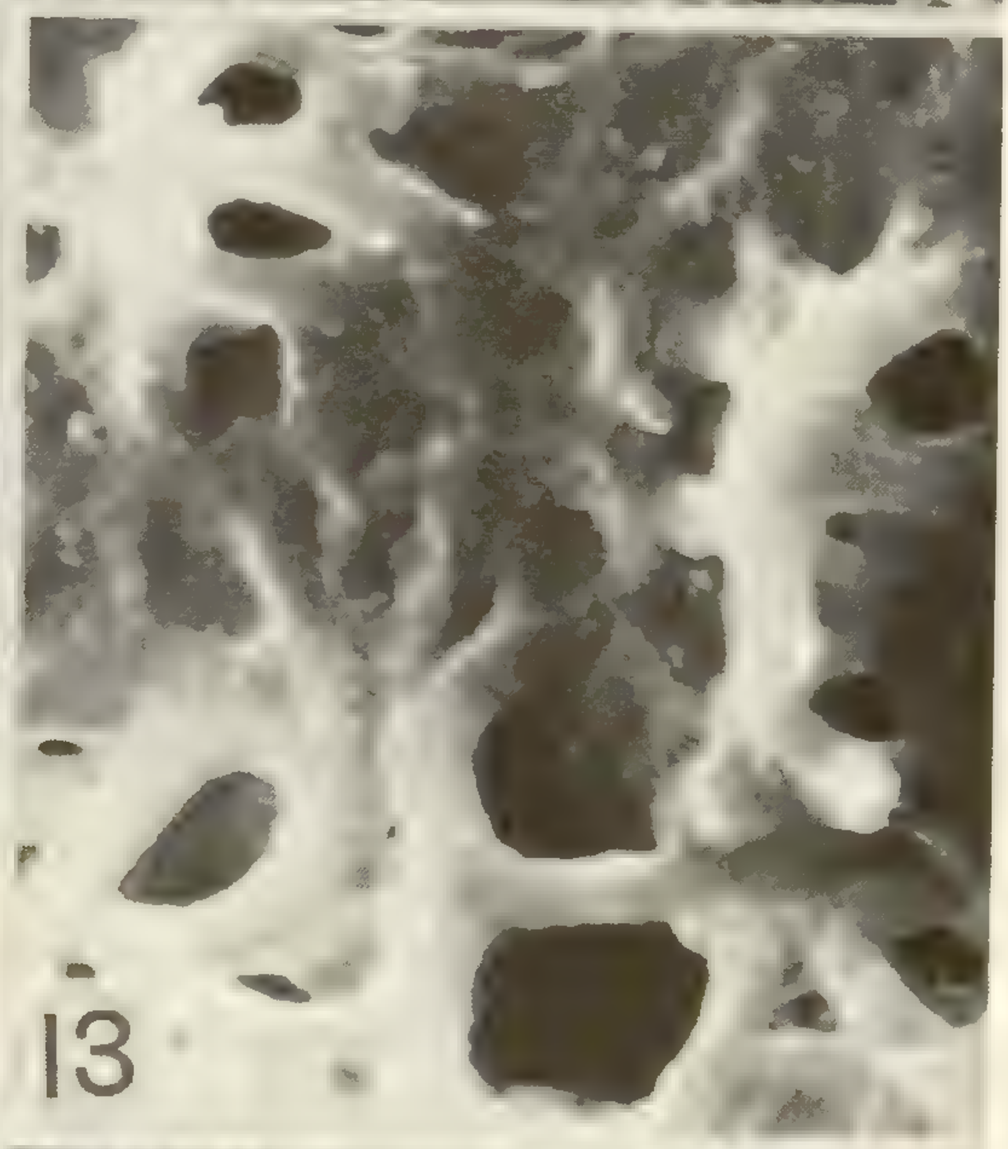
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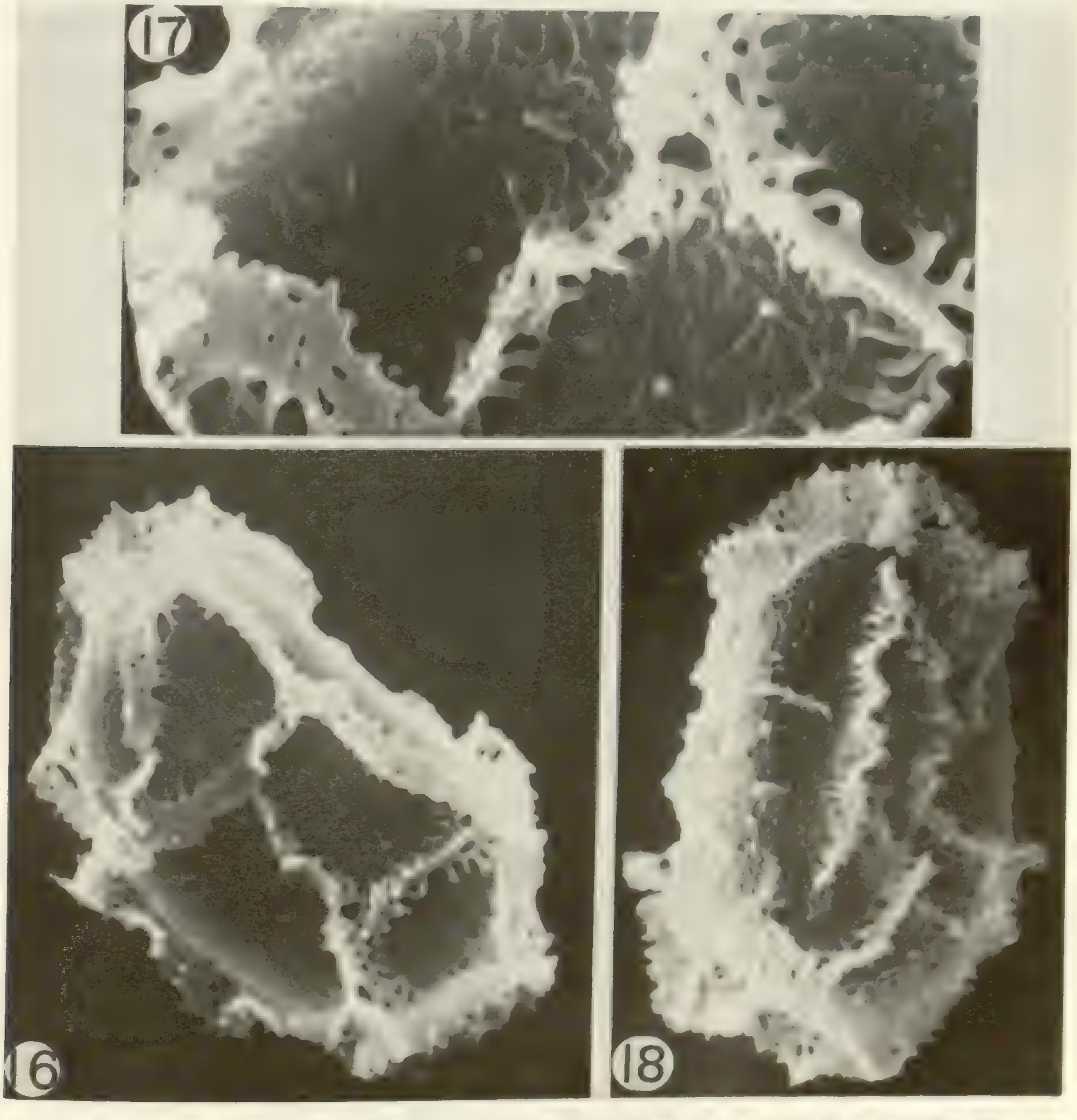
(*Fig. 15*) are areolate near the base and irregularly papillate along their edges. The perine in the spores of *Thelypteris japonica* (*Fig. 18*) is similar to that of the spores of *T. simulata,* but has more prominent ridges.



Thelypteris spores. Figs. 16, 17. *T. nipponica, Iwatsuki 2176,* Hokkaido, Japan (GH). Fig. 16. Reticulate perine, ca. × 1200. Fig. 17. Detail of reticulate surface and areolate ridges, ca. × 5000. Fig. 18. *T. japonica,* the perine with perforate ridges with papillate edges, *Kume,* in 1925, Nara, Japan (GH), ca. × 1200.

Thelypteris spores. Figs. 10, 11. *T. palustris, A. Tryon 70-18,* Mass. Fig. 10. Verrucate perine ca. × 1300. Fig. 11. Detail of surface papillae, ca. × 5000. Figs. 12, 13. *T. noveboracensis, A. Tryon 69-5,* Mass. Fig. 12. Reticulate perine, ca. × 1300. Fig. 13. Detail of reticulum with large areolae, ca. × 5000. Figs. 14, 15. *T. simulata, A. Tryon 69-6,* Mass. Fig. 14. Perforate perine ridges, the commissural ridge slightly above center, extending most of the length of the spore, ca. × 1500. Fig. 15. Detail of the perine surface, the ridges with basal areolae and papillate edges, ca. × 5000.

GEOGRAPHY

The geographic relationships of the three species of *Thelypteris* in eastern North America with eastern Asia represent a well known pattern that occurs in lichens, mosses, liverworts, and flowering plants, as well as in ferns. This pattern is a strong one in the ferns, for about 20% of the species in eastern North America (excluding tropical elements in the southeastern United States) show disjunct

TABLE 2. EASTERN NORTH AMERICAN PTERIDOPHYTA WITH DISJUNCT GEOGRAPHIC OR TAXONOMIC RELATIONS IN EASTERN ASIA.

Eastern No. Amer.	*Western No. Amer.*	*Eastern Asia*	*Europe*
Pteridium aquilinum var. latiusculum		X	X
Thelypteris palustris var. pubescens		X	
Adiantum pedatum var. pedatum	X	X	
Asplenium septentrionale	X	X	X
Asplenium viride	X	X	X
Diplazium thelypterioides		X	
Lycopodium lucidulum		X	
Lycopodium obscurum	X	X	
Onoclea sensibilis		X	
Osmunda cinnamomea var. cinnamomea		var. asiatica	
Osmunda claytoniana var. claytoniana		var. vestita	
Osmunda regalis var. spectabilis		var. japonica	var. regalis
Phyllitis scolopendrium var. americanum		var. scolopendrium	var. scolopendrium
Polystichum braunii var. purshii	var. alaskense	var. braunii var. kamtschaticum	var. braunii
Asplenium cryptolepis		A. ruta-muraria	A. ruta-muraria
Camptosorus rhizophyllus		C. sibiricus	
Dennstaedtia punctilobula		D. appendiculata	
Diplazium pycnocarpon		D. scabra	
		D. cavalerianum	
		D. javanicum	
Polypodium virginianum	P. hesperium	P. fauriei	P. australe
Thelypteris noveboracensis	T. nevadensis	T. beddomei	
		T. nipponica	
Thelypteris simulata		T. glanduligera	
		T. japonica	

affinities with species of eastern Asia. The primary geography of these species and their vicarious relatives is shown in *Table 2*. A few of the taxa have disjunct areas in other regions (see Hultén, 1958, 1962).

Recent studies of both fossil and living floras indicate that floristic relationships between the two areas are complex (Graham, 1972). Since the early Tertiary there were several times when land and climates in the Bering Strait

region were suitable for migration of temperate species, and repeated invasions surely occurred. There may be a correlation between the divergence of taxa (*Table 2*) and their periods of isolation. The vicarious species in *Camptosorus, Dennstaedtia, Diplazium, Thelypteris,* and *Polypodium* may represent an old floristic element resulting from early migration and isolation. Taxa that are undifferentiated in the two regions, for example, *Thelypteris palustris* var. *pubescens, Diplazium thelypterioides, Onoclea sensibilis,* and *Lycopodium lucidulum,* may represent a younger floristic element that has migrated more recently. However, vicarious species or varieties may have diverged during recent migration as in the case of *Selaginella* (R. Tryon, 1971). Differences in breeding systems and population structure, and in the genetic variability of species will also influence the amount of divergence during comparable time intervals.

Migration is usually considered to be in an eastward direction across the Bering Strait from Asia to North America. The greater diversity of several species groups in eastern Asia, as in *Thelypteris, Dennstaedtia,* and *Diplazium,* implies longer occupancy in that region. However, evidence is needed for the occurrence of primitive taxa in eastern Asia and derived ones in North America.

Several species of European ferns may have migrated to North America. For example, cytological studies on *Phyllitis scolopendrium* have indicated that var. *scolopendrium* in Europe is diploid, while var. *americana* is tetraploid. In several genera of ferns there is evidence that distant areas have been reached by long distance dispersal. *Asplenium septentrionale* is of local occurrence in specialized habitats throughout its disjunct range. It probably was established in eastern North America by long distance migration.

Three species of *Thelypteris* in eastern North America, *T. palustris, T. noveboracensis* and *T. simulata* are distinctive, and there is no evidence of hybrids between them. Their discrete chromosome numbers, 27, 35, and 64, and distinct types of perine of the spores illustrate differences between them and some similarities with species of eastern Asia. An analysis has been made of the geography of these species and other Pteridophyta of eastern North America that have disjunct relations with eastern Asia. It is suggested that nomenclaturai changes of the Marsh Fern await further study of type materials and a thorough systematic account of the species throughout its broad geographic range.

LITERATURE CITED

BRITTON, D. M. 1953. Chromosome studies on ferns. Amer. J. Bot. **40:** 575–583.
———. 1964. Chromosome numbers of ferns in Ontario. Canad. J. Bot. **42:** 1349–1353.
CHAMBERS, T. C. 1955. Use of snail stomach cytase in plant cytology. Nature **175:** 215.
DAVENPORT, G. E. 1894. Two new ferns from New England. Bot. Gaz. **19:** 492–497.
———. 1896. New or little-known plants, Aspidium simulatum, Davenport. Garden Forest **9:** 484–486.
EATON, D. C. 1870. Notes on some of the plants in the herbaria of Linné and Michaux. Canad. Nat. **13** [n. s. **5**]: 24–31.
———. 1879. The ferns of North America, Vol. 1.
FERNALD, M. L. 1929. A study of Thelypteris palustris. Rhodora, **31:** 27–36.
GRAHAM, A. [Ed.] 1972. Foristics and paleofloristics of Asia and eastern North America.

GRAY, A. 1848. Manual of the botany of the northern United States.
HARTLEY, T. G. 1965. Discovery of the Massachusetts Fern in Wisconsin. Rhodora **67:** 399–401.
HIRABAYASHI, H. 1969. Chromosome numbers in several species of the Aspidiaceae. J. Jap. Bot. **44:** 113–119.
HOLUB, J. 1972. On the taxonomy and nomenclature of the European Marsh Fern. Taxon **21:** 331–332.
HULTÉN, E. 1958. The amphiatlantic plants. Kongl. Svenska Vetenskapsakad. Handl. IV, **7**(1): 1–340.
————. 1962. The circumpolar plants. I. Kongl. Svenska Vetenskapsakad. Handl. IV, **8**(5): 1–275.
MANTON, I. 1950. Problems of cytology and evolution in the Pteridophyta.
MAXON, W. R. and C. V. MORTON. 1938. American species of Dryopteris subgenus Meniscium. Bull. Torr. Bot. Club **65:** 347–376.
MICHAUX, A. 1803. Flora Boreali-Americana, Vol. 2.
MITUI, K. 1968. Chromosomes and speciation in ferns. Sci. Rep. Tokyo Kyoiku Daigaku. B, **13:** 285–333.
MORTON, C. V. 1958. The Californian species of Thelypteris. Amer. Fern J. **48:** 136–142.
————. 1963a. Some West Indian species of Thelypteris. Amer. Fern J. **53:** 57–70.
————. 1963b. The classification of Thelypteris. Amer. Fern J. **53:** 149–154.
————. 1967a. Studies of fern types, I. Contrib. U. S. Nat. Herb. **3:** 29–83.
————. 1967b. The fern herbarium of André Michaux. Amer. Fern J. **57:** 166–182.
OLIVER, J. C. 1969. Biosystematic studies of the beech and marsh ferns. Proc. Indiana Acad. Sci. **79:** 388–395.
SMITH, A. R. 1971. Chromosome numbers of some new world species of Thelypteris. Brittonia **23:** 354–360.
SORSA, V. 1958. Chromosome studies on Finnish Pteridophyta, I. Hereditas **44:** 541–546.
TRYON, A. F. 1971. Structure and variation in spores of Thelypteris palustris. Rhodora **73:** 444–460.
TRYON, R. 1971. The process of evolutionary migration in species of Selaginella. Brittonia **23:** 89–100.
WAGNER, W. H. 1955. Cytotaxonomic observations on North American ferns. Rhodora **57:** 219–240.
————. 1963. A biosystematic survey of United States ferns—preliminary abstract. Amer. Fern J. **53:** 1–16.

Fern Foods of Japan and the Problem of Toxicity

W. H. HODGE*

As much as any other people the Japanese appreciate and continue to utilize a variety of their native wild plants as specialty foods. The suitability of a number of species of their rich island flora for "emergency" food must have been learned in earliest times. This knowledge culminated in the production of so-called "famine herbals," which were illustrated books describing wild plants that could serve as food in periods of scarcity. Such herbals appeared in Japan principally in the 17th and 18th centuries (Bartlett & Shohara, 1961).

The fact that the Japanese have been essentially the exclusive occupants of their archipelago for centuries also helps to explain the widespread knowledge of native plants and their uses which persists even today in that very modern and highly industrialized nation. In contrast, in the United States where urbanization has been the rule, the familiarity and use of edible wild plants that formerly existed is rapidly being reduced to book knowledge. A recent residence in Japan (1966–1970) demonstrated to me that a surprising number of native edible plants are still known and harvested for food in rural Japan. These are not only used locally, but are made available, often in modern packaging, to urban residents either in specialty food shops in the major cities or more frequently at small tourist centers or spas that exist throughout the islands.

Among the best known and most popular of wild vegetable foods are the tender croziers of certain ferns. Most common are those of the cosmopolitan and weedy Bracken (*Pteridium aquilinum* var. *latiusculum*), called "Warabi" in Japanese. Croziers of the native Royal Fern (*Osmunda japonica*) known as "Zenmai" are also appreciated. Although several other species of *Osmunda* having esculent croziers are native to Japan, including *O. asiatica* (the Asiatic equivalent of *O. cinnamomea*) and *O. claytoniana,* no reference is known to me of their use in that country. This seems curious, for the young shoots of both the Cinnamon Fern and the Interrupted Fern of North America have been recorded as edible (Stone, 1903).

In one or another of its varieties the ubiquitous Bracken has been used as an occasional wild food source in many parts of the world and especially in Japan. Sturtevant has summarized these uses (see Hedrick, 1919). In Japan the "fiddleheads" or croziers of Bracken have probably been long used as a green vegetable in spring and were noted as "edules" by Thunberg (1784). Additionally, the rhizomes of this species are sometimes dug for the production of starch for food or for making paste (Takashima, 1964). Most Japanese are familiar with Warabi croziers as a specialty food, although perhaps they are unaware of the possible toxicity of these shoots as reported below.

According to Takashima (1964), selections of wild Bracken having superior food quality were made during the last decade of the past century and these

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Fig. 1. Preparing Warabi shoots for drying in rural Honshu near the village of Shirakawa, Gifu Prefecture. Fig. 2. Fern croziers being sun-dried in Tottori Prefecture. Fig. 3. Pickled Warabi ("tsukemono") for sale in bulk in an open air market at Takayama, Gifu Prefecture. Fig. 4. Fern shoots packaged in Japan for sale in shops abroad. At left, a package of dried *Osmunda japonica* ["Akaboshi zenmai"—Sun-dried Royal Fern] purchased in Honolulu. At right, pickled shoots of *Pteridium* ["Meisan-Hidazuke Aji-Warabi"—famous Hida (Gumma Prefecture) pickle made from tasty Warabi] from a shop in Washington, DC.

apparently are still being maintained in cultivation. These clones are said to produce essentially hairless croziers which also have a more attractive green color. In order to extend the season for fresh shoots, dormant rhizomes are often dug late in the year and are forced in special beds or in temporary vinyl greenhouses, so much used today in Japan for producing winter vegetables. Forced in such fashion at a temperature of 17°–20° C, Warabi is said to produce shoots that can be cut regularly (once a length of 6 cm is attained) over a period of about a month (Takashima, 1964).

In Japan young shoots of Warabi (or Zenmai) are either used as a fresh vegetable in spring or they are salted, sun-dried, or pickled for future use. In the spring, families in rural Japan still seek out with pleasure their favorite Warabi "patch" to harvest the tender young shoots for home use (*Fig. 1*). The freshly picked croziers are usually prepared for eating by immersing briefly in boiling water like asparagus. Since the shoots have a slightly bitter taste, the boiling water in which they are immersed usually has a little wood ash or sodium bicarbonate added to eliminate the bitterness. They are again boiled in plain water, then served, flavored usually with fish powder and soy sauce. Apart from the addition of these typical oriental seasonings, this is essentially the same preparation suggested for Bracken shoots by Fernald and Kinsey (1943).

The processes of salting, drying, or pickling have served to extend the availability of young fern shoots throughout the year and also have permitted wider distribution of this unique food. Fresh Bracken shoots stored in salt are simply boiled prior to use. Croziers to be dried are first immersed in boiling water with wood ash. They are then sun dried on mats (*Fig. 2*) in any convenient location, after which they are packaged. The dried product is normally soaked for 24 hours in cold water in order to soften it prior to cooking and subsequent preparation for eating in the same manner as with freshly cooked shoots.

The pickling of many kinds of vegetables and fruits as a means of preservation was developed very early in Japan. Today such pickled material ("tsukemono") is still a unique but characteristic part of the daily diet and is served as a side dish at all Japanese meals. Because of the method of marination, Japanese pickles have a distinct taste unlike that of pickles produced in western countries. Fern shoots are regularly pickled in the manner used for most vegetables by covering them with a soft paste of bran and salt in large tubs. Like other pickles, fern "tsukemono" is sold either in bulk from the pickling tub (*Fig. 3*) or in individual packages. The latter, as with similar packets of dried shoots (*Fig. 4*), are widely distributed within Japan or to wherever a demand for these unusual products exists, including the United States.

Although *Pteridium* fronds, when eaten, have long been known to poison livestock, only in recent years has it been learned that one or more toxins which are radiomimetic in character and which have strong carcinogenic activity also exist in Bracken. Working in Wales, Evans and Mason (1965) first demonstrated that laboratory rats fed dried, pelleted Bracken invariably develop multiple intestinal tumors. Pamukcu and Price (1969), reporting on similar studies, suggest

that the high incidence of human stomach cancer in Japan may possibly be explained in part by the consumption of significant quantities of fresh Bracken shoots by the population of that country.

Further research in Japan by Hirono et al (1972) has demonstrated that local Bracken shoots, as prepared for human consumption, produce a high incidence of intestinal tumors (78.5%) in rats when the shoots are simply processed in boiling water without wood ash. When processed in boiling water with wood ash (or with sodium carbonate or NaCl) they report that the tumor incidence was reduced to 25%. They emphasize that although the carcinogenic activity of *Pteridium* can be reduced remarkably by the usual treatment employed in Japanese homes where Bracken is eaten, nonetheless weak cancer-producing activity still exists in the resulting food product. The Hirono group also observes that variation exists in the carcinogenic activity of Bracken obtained from different parts of Japan. Hokkaido Bracken (43°N) produces stronger carcinogenicity than bracken collected 800 km further south in the mountains of Gifu Prefecture (35°N). They suggest that differing geographical conditions may be a cause of this variation. Actually, scientists know very little about the production of chemical constituents in plants or the causes for variation in concentration, which is a common occurrence among such familiar natural products as the plant alkaloids. Both internal and external factors must be considered.

Although the identity of Bracken toxin(s) is yet to be determined, it seems clear from contemporary research that the principle involved is both carcinogenic and mutagenic in several kinds of test animals. Thus, it appears wise to recommend that the tender, young shoots of Bracken, so long and so widely utilized as an occasional human food, should not be eaten. Botanists can alert the public by removing *Pteridium aquilinum* from their lists of edible wild plants and placing this common fern on lists of plants having apparent toxic properties.

LITERATURE CITED

BARTLETT, H. H. and H. SHOHARA. 1961. Japanese botany during the period of wood-block printing. Los Angeles.

EVANS, I. A. and J. MASON. 1965. Carcinogenic activity of Bracken. Nature **208:** 913–914.

FERNALD, M. L. and A. C. KINSEY. 1943. Edible wild plants of eastern North America. Cornwall-on-Hudson.

HEDRICK, V. P. (ed.). 1919. Sturtevant's Notes on Edible Plants. Albany.

HIRONO, I., C. SHIBUYA, M. SHIMIZU, and K. FUSHIMI. 1972. Carcinogenic activity of processed Bracken used as human food. J. Nat. Cancer Inst. **48:** 1245–1250.

PAMUKCU, A. M. and J. M. PRICE. 1969. Induction of intestinal and urinary bladder cancer in rats by feeding bracken fern. J. Nat. Cancer Inst. **43:** 275–281.

STONE, G. E. 1903. Edible weeds and pot herbs. Commonwealth of Massachusetts, State Board of Agriculture, Nature Leaflet No. 19.

TAKASHIMA, S., K. NIIUCHI, and H. WATANABE. 1964. Pteridium aquilinum Kuhn var. japonicum Nakai *in* Vegetable crops of Japan in colour [in Japanese]. Hoikusha, Osaka.

THUNBERG, C. P. 1784. Flora Japonica. Lipsiae.

The Identity of Three Type Specimens in the Willdenow Herbarium

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During a recent visit to Berlin I examined the types of three species of Thelypteridaceae in the Willdenow Herbarium that have been variously misinterpreted in the past. As a result of my study of these species and of past misidentifications, I here publish the new combinations *Amphineuron terminans* (Hooker) Holtt. and *Christella prolixa* (Willd.) Holtt. My thanks are due to Dr. Th. Eckardt, Director of the Botanical Museum at Berlin-Dahlem, for permission to study the Willdenow types, and to Dr. D. E. Meyer for much kind help during my visit.

PTERIS INTERRUPTA

The type of *Pteris interrupta* Willd., collected by Klein in southern India (Herb. Willd. no. 19770), was certainly misinterpreted by Ching (1933, p. 566). It was correctly identified by Fosberg and Sachet (1972, p. 8) on the basis of a fragment which they found in the British Museum herbarium. Fosberg and Sachet cite as synonyms *Polypodium tottum* Thunb. and *Aspidium goggylodus* Schkuhr, stating that these names refer to a "common pantropical marsh fern" which "for a pantropical species . . . shows remarkably little variability over most of its range." I would say, however, that the range of variability is considerable and that it is difficult to interpret.

Mettenius (1864, p. 230), accepting (under the name *Aspidium unitum*) the species in the broad sense adopted by Fosberg and Sachet, divided it into two varieties which he called var. *glabra* and var. *hirsuta*. Morton (1967, p. 73) accepted these two varieties. But I have not found clear-cut glabrous and hairy varieties; there are graduations of hairiness, differences in the occurrence and distribution of the large red glands, and sometimes in the presence of short, capitate hairs in addition to (or in place of) acicular hairs. An indication of the factors to be reckoned with is given by T. G. Walker (1966, pp. 179, 214), who reports that a plant examined by him in Jamaica was tetraploid, whereas plants previously examined in Ceylon, Japan, Tanganyika, and New Zealand had been diploid. A. R. Smith (1971, p. 27) also reports a tetraploid from Florida. These tetraploids are very glabrous, as are the types of *Polypodium tottum* and *Aspidium goggylodus*. But Willdenow's type is smaller and is hairy on the lower surface; it is closely similar to the Ceylon plant which Manton and Sledge (1954, p. 138) found to be diploid. The existence of diploids (if any) in the New World needs to be established and their macroscopic characters described. If the tetraploids are allotetraploid, two diploid genomes must exist. The extent to which environmental conditions determine some vegetative characters also needs to be established.

It appears, therefore, that we are dealing with a macrospecies, or species-complex, which needs cytotaxonomic study with attempts at hybridization for the

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resolution of its constituent elements. This species-complex, together with the apparently distinct diploid African species *Aspidium striatum* Schum., constitutes the genus *Cyclosorus* Link *s. str.* (Holttum, 1971, p. 28). As an indication of the nomenclatural problems which may arise, it should be noted that at least 17 binomials, based on different types, refer to plants belonging to the complex: *Pteris interrupta* Willd. 1794 (India), *Polypodium tottum* Thunb. 1800 (So. Africa), *Aspidium obtusatum* Swartz 1801 (Java), *Pteris polypodioides* Poir. 1804 (Brazil); *Aspidium goggylodus* Schkuhr 1809 (Guiana), *Nephrodium propinquum* R. Brown 1810 (Australia), *Aspidium pohlianum* Presl 1822 (Brazil), *Aspidium resiniferum* Kaulf. 1824 (Hawaii), *Nephrodium venulosum* Desv. 1827 (Mauritius), *Aspidium venulosum* Blume 1828 (Java), *Hypopeltis propinquoides* Bory 1833 (Java), *Hypopeltis marginifera* Bory 1833 (Java), *Aspidium ecklonii* Kunze 1836 (So. Africa), *Goniopteris cheilocarpa* Fée 1852 (Brazil), *Nephrodium paludosum* Liebm. 1849 (Mexico), *Aspidium aneitense* Fourn. 1873 (New Caledonia), and *Nephrodium inaequilaterum* Colenso 1888 (New Zealand).

In their paper of 1972, having shown that Ching misinterpreted the name *Pteris interrupta* Willd., Fosberg and Sachet provided a new name *Thelypteris wagneri* for the species to which Ching applied the name *Dryopteris interrupta*. But they overlooked the fact that Hooker had already provided a valid name for Ching's species. Hooker's description is quite good, and he cited 15 specimens (mostly omitted from the list given by Fosberg and Sachet), all but one of which are correct. Hooker's specific epithet was taken from Wallich, who gave the manuscript name *Aspidium terminans* to his no. 386, a specimen of which is among the specimens at Kew from Hooker's herbarium; there is a blank under this number in the Wallich herbarium. The essential synonymy is as follows; in it the specific epithet is transferred to the genus *Amphineuron* (Holttum, 1971, p. 45).

Amphineuron terminans (Hooker) Holtt., comb. nov.

Nephrodium terminans Hooker, Sp. Fil. **4:** 73. 1862. TYPE: Kamoun, India, *Wallich 386* (K).

Dryopteris pteroides sensu C. Chr. Ind. Fil. 287. 1905, *pro parte, non Polypodium pteroides* Retz.

Dryopteris interrupta sensu Ching, Lingnan Sci. J. **12:** 566. 1933, *nec Pteris interrupta* Willd. *nec Cyclosorus interruptus sensu* Ching,[1] Bull. Fan Mem. Inst. Biol. Bot. **8:** 184. 1938.

ASPIDIUM PROLIXUM

The type of *Aspidium prolixum* Willd. (Herb. Willd. no. 19783) was collected by Ventenat, at an unrecorded locality on the d'Entrecasteaux Expedition. It consists of one complete frond mounted on two sheets. It is certainly closely allied to *Aspidium obliquatum* Mett. of New Caledonia, with which it agrees in details of sori, pubescence, venation, and shape of frond. (New Caledonia was visited by Ventenat's expedition in April 1793.) It differs from the type collection of *A.*

[1] *Cyclosorus interruptus* was used in this sense also by Holttum (Rev. Fl. Malaya **2:** 262, *f. 149*. 1954) and by Copeland (Fern Fl. Phil. 361. 1960).

obliquatum, of which there is a duplicate at Kew, in having the lobes of the pinnae less oblique and the basal acroscopic lobes of the lowest three pairs of pinnae enlarged and lobed with veins pinnate in the lobes. On the herbarium specimens of *A. obliquatum* at Kew, at most the basal acroscopic lobes of the basal pinnae have this character, and sometimes they appear to be entire with mostly simple veins (in some cases they are not clearly observable). I refrain from placing Mettenius' name as a synonym of Willdenow's until examination of more ample material from New Caledonia is possible (the species is a common one there). But certainly *A. prolixum* Willd. belongs to the genus *Christella* Lév. as I have redefined it (Holttum, 1971, p. 43), and I therefore propose the new combination:

Christella prolixa (Willd.) Holttum, comb. nov.

Aspidium prolixum Willd. Sp. Pl. ed. 4, 5: 251. 1810.

Hooker omitted reference to *A. prolixum* in his "Species Filicum," but Baker adopted it (with transference to *Nephrodium*) in the "Synopsis Filicum" (p. 268) and applied the name to Indian and Chinese specimens which I would regard as belonging to four distinct species, namely *Thelypteris ochthodes* (Kunze) Ching, *T. tylodes* (Kunze) Ching, *T. repens* (Hope) Ching, and *T. esquirolii* (Christ) Ching. Baker also added specimens from Mauritius and Réunion which I believe belong to *Aspidium pulchrum* Willd. (see below); in this he was followed by Christensen (1932b, p. 46). These ferns of India and Mauritius are certainly not nearly allied to Willdenow's specimen.

ASPIDIUM PULCHRUM

The type of *A. pulchrum* Willd. (Herb. Willd. no. 19787) was collected by Bory de St. Vincent, who supplied the specific epithet. Willdenow gives Bourbon [i.e., Réunion] as the locality, but this is not written on the herbarium sheet. There is, however, a folded paper on which is a sketch by Bory of the habit of the fern, which he described as "plus que trois pieds de haut, très élégante." The specimen consists of one pair of pinnae, 24 × 3.2 cm, with swollen aerophores at their bases. These pinnae agree well with specimens from Réunion and Mauritius in the Kew herbarium which Schelpe identified as *Thelypteris zambesiaca* (Baker) Tard., a name which Schelpe (1970, p. 192) later listed as a synonym of *T. longicuspis* (Baker) Schelpe, the type of which is a smaller but otherwise similar fern from Madagascar. The only discrepancy is that Bory's sketch showed the lower pinnae (unfortunately lacking from his specimen) as gradually decrescent, whereas the Kew specimens mentioned above certainly have an almost abrupt transition from the larger pinnae to the small ones at the base of the frond. I have little doubt that Bory's specimen represents the same species as those now at Kew, in which case the epithet *pulchra* should replace *longicuspis*. But I am in doubt as to which generic group it belongs to. It seems to me probable that *A. pulchrum* is allied to the species of India and China mentioned above under *A. prolixum* that Ching (1963, p. 322) has included in his genus *Pseudocyclosorus*. In 1971 I included this in *Pneumatopteris* (Holttum, 1971, p. 42), but now I am inclined to accept it as a separate genus. This group of ferns, along with some other African free-

veined species of Thelypteridaceae, needs a new and detailed comparative study, and I suggest that no new combinations ought to be published until this has been undertaken.

Christensen (1932a, p. 24) listed *A. pulchrum* as a synonym of *A. strigosa* Willd., but the latter is a much smaller fern with large, red glands on the lower surface and quite gradually reduced lower pinnae; it belongs to another species-group, certainly not to *Pseudocyclosorus*. Christensen failed to mention *A. pulchrum* in his fern flora of Madagascar (1932b).

LITERATURE CITED

CHING, R. C. 1933. Notes on the Herbarium Willdenow. Lingnan Sci. J. **12:** 565–570.

————. 1963. A reclassification of the family Thelypteridaceae from the mainland of Asia. Acta Phytotax. Sinica **8:** 289–335.

CHRISTENSEN, C. 1932a. Catalogue des plantes de Madagascar, Pteridophyta. Academie Malgache, Tanarive.

————. 1932b. The Pteridophyta of Madagascar. Dansk Bot. Ark. **7:** 1–253, *t. 1–80.*

FOSBERG, F. R. and M.-H. SACHET. 1972. Three Indo-Pacific Thelypteroid species reinterpreted and a new African species described. Smiths. Contr. Bot. **8:** 1–10.

HOLTTUM, R. E. 1971. Studies in the family Thelypteridaceae III. A new system of genera in the Old World. Blumea **19:** 17–52.

MANTON, I. and W. A. SLEDGE. 1954. Observations on the cytology and taxonomy of the pteridophyte flora of Ceylon. Phil. Trans. Roy. Soc. B, **238:** 127–185.

METTENIUS, G. 1864. Filices, praesertim indicae et japonicae. Ann. Mus. Bot. Ludg.-Bat. **1:** 222–241.

MORTON, C. V. 1967. Studies of fern types, I. Contr. U. S. Nat. Herb. **38:** 29–83.

SCHELPE, E. A. C. L. E. 1970. Flora Zambesiaca, Pteridophyta. 254 pp. Crown Agents, London.

SMITH, A. R. 1971. Systematics of the neotropical species of Thelypteris section Cyclosorus. Univ. Calif. Publ. Bot. **59:** 1–136.

WALKER, T. G. 1966. A cytotaxonomic survey of the pteridophytes of Jamaica. Trans. Roy. Soc. Edinb. **66:** 169–237.

Some Notes on the Gemmiferous Species of Asplenium in Tropical East Africa[1]

R. B. FADEN*

There is no general account of the pteridophytes for the area of the Flora of Tropical East Africa (Kenya, Uganda, and Tanzania). Extensive collections and searches of the literature and available herbarium material have indicated the presence of approximately 420 species, among which are about 75 species of *Asplenium*. Of the latter, not less than 24 (32%) have been found to regularly or occasionally produce gemmae on their fronds. It is interesting to note that nearly the same percentage of gemmiferous species occurs in other parts of tropical Africa: Flora of West Tropical Africa area, 16 of 49 (33%) species gemmiferous (Alston, 1959); Madagascar and the Comoro Islands, 19 of 58 (33%) species gemmiferous (Tardieu-Blot, 1958); Flora Zambesiaca area, 13 of 41 (32%) species gemmiferous (Schelpe, 1970).

The gemmiferous species of *Asplenium* in East Africa can be divided into five groups on the basis of the position of the gemmae on the fronds. The groups are not intended to be natural, but they often do contain taxonomically closely related species. The possible relationships among the species in each group are discussed in the account of the group.

THE GROUPS OF GEMMIFEROUS SPECIES

In Group I an apical or subapical gemma is produced on the terminal pinna and sometimes also on the lateral pinnae. The fronds are simple or pinnate with few, relatively large pinnae. The terminal pinna is similar in cutting to the lateral pinnae. The East African species in this group are *A. emarginatum* Palisot, *A. variabile* Hooker, and *A. paucijugum* Ballard (which I consider distinct from *A. variabile*). Additional species occur in Madagascar and in West Africa. All of the species in Group I appear to be related and to form a natural group.

One species, *A. angolense* Baker, which is morphologically similar and probably related to the above species, is peculiar in having the gemma on the adaxial side of the costa of the terminal pinna about halfway between the base and the apex. In recent years it has been found in East Africa, having previously been known only from Angola: UGANDA, Kigezi District, South Maramagambo Central Forest Reserve, alt 1050–1150 m, 18 Sept 1969, *Faden 69/1112* (EA); KENYA, Kakamega District, Kakamega Forest, 0°11′N, 34°52′E, alt ca 1600 m, 20 Jan 1970, *Faden 70/1* (BOL, BR, EA, Herb. Pic. Ser., K, LISC, MO, SRGH, US, WAG); same forest, 0°21′N, 34°53′E, alt ca 1680 m, 27 Dec 1969, *Faden*

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[1] The author wishes to thank Dr. P. G. Holland for reading the manuscript; Ms. C. H. S. Kabuye, Botanist-in-Charge of the East African Herbarium, for use of the Herbarium's facilities; and the Photographic Section of the National Museums of Kenya for assistance with the photography.

69/2112 (EA, K); same forest, Lirhanda (Pillar) Hill, alt 1744 m, 26 Dec 1969, *Faden 69/2099* (EA).

In Group II, the largest group of gemmiferous species, a single (or rarely more than one) gemma is produced on the rachis, generally at the base of the terminal pinna, which is usually different in cutting from the lateral pinnae. The constancy of gemma presence varies from species to species; they are nearly always present in *A. bugoiense* Hieronymus, *A. dregeanum* Kunze, and *A. macrophlebium* Baker; frequently they are absent in some fronds of *A. protensum* Schrader; often they are absent in whole plants or even in whole populations of *A. normale* D. Don. Some other examples of East African species in this group are: *A. barteri* Hooker, *A. blastophorum* Hieronymus, *A boltonii* Hooker ex Schelpe, *A. christii* Hieronymus, *A. elliottii* C. H. Wright, and *A. gemmiferum* Schrader.

A number of different evolutionary lines are represented by the species in Group II, which is widespread in tropical and South Africa. The dareoid East African species *A. bugoiense, A. dregeanum, A. pseudoauriculatum* Schelpe, and at least one undescribed species, represent one natural group; *A. barteri, A. macrophlebium,* and *A. christii* constitute another. *Asplenium elliottii* and *A. boltonii* form a third group, but *A. blastophorum* shows closer relationships with non-gemmiferous species than with any other Group II species. Similarly, *A. normale* is taxonomically closer to *A. monanthes* L. of Group III than it is to other species in its own group.

Asplenium gemmiferum has been placed in Group II on the basis of the position of the gemmae. It differs from all other species in this group in having its terminal pinna similar in cutting to the lateral pinnae, a characteristic of the Group I species. It is also like Group I species in having few, relatively large pinnae. Probably its overall morphological similarity to Group I species is more indicative of its true taxonomic relationship than is the gemma position.

In Group III a gemma is sometimes produced on the stipe but never on the lamina of the fronds. The sole East African representative is the tropical American and tropical and South African species *A. monanthes* L. *Asplenium lobatum* Pappe & Rawson of southern Africa and Madagascar sometimes produces a gemma at the base of the lamina (Schelpe, 1970) and may belong to this group, but it does not appear to be very closely related to *A. monanthes*. The latter is closest to *A. normale* of Group II among East African species (see above).

In Group IV the pinnate fronds lack a terminal pinna, and the elongated rachis ends in a gemma. The gemma is not truly terminal, but it appears to be so because the frond apex aborts just after the gemma is produced. Thus the gemma is lateral, as it is in *A. stoloniferum* Bory (see p. 89). The fronds arch and touch the substrate, where they produce new plants at the frond apex. The plants are therefore "walking ferns" with the habit of *Camptosorus*. The only East African species is the widespread continental African and Madagascan *A. sandersonii* Hooker. Tardieu-Blot (1958) cites two additional species from Madagascar which seem to belong to this group. On the basis of their descriptions, neither *A. tsaratananense* Tardieu nor *A. mangindranense* Tardieu appear to be closely re-

lated to *A. sandersonii,* the taxonomic relationships of which are not very clear, but may perhaps lie among the dareoid *Asplenium* species.

The species in Group V have dimorphic fronds, normal soriferous fronds, and fronds which lack a lamina. The latter produce one or more gemmae and may have determinate or indeterminate growth. These are discussed below. The sole East African representative of this group is the widespread tropical African *A. mannii* Hooker. *Asplenium stoloniferum* Bory (syn. *A. kraussii* Moore, *fide* Schelpe, 1969) of South Africa and the Mascarene Islands, also belongs to this group, but is not closely related to *A. mannii* (see p. 89).

STOLONOID FRONDS IN ASPLENIUM MANNII

Asplenium mannii Hooker has been described in all recent African fern floras (Schelpe, 1970; Tardieu-Blot, 1953, 1958, 1964; Alston, 1959) as stoloniferous. After having examined living plants of this species from East Africa (KENYA, Embu District, Mt. Kenya SE, Irangi Forest Station, 0°21′S, 37°27′E, alt ca 2000 m, 30 Apr 1972, *Faden & Holland 72/187,* EA) and specimens in the East African Herbarium, it has become clear that the nature of the "stolons" has been misinterpreted. These "stolons" are not stems, but are procumbent fronds which lack a lamina. They usually have indeterminate growth and are produced for vegetative reproduction.

The most obvious frond character of the stolonoid fronds is their termination in croziers. The fiddleheads are partially covered by very irregular, colorless, thalloid scales which have moniliform hairs on their margins. These hairs are 2–6 cells long, and the terminal cell of each is slightly enlarged. With age the cells of the scale die. The centers of the cells remain colorless while the walls between adjacent cells become reddish-brown, thus forming the typical clathrate paleae of *Asplenium*. These paleae are quite different from those of the rhizome, but are identical to those of the stipe, rachis, and lamina of normal fronds. Under a dissecting microscope, a crozier of a stolonoid frond is indistinguishable from a young crozier of a normal soriferous frond unless the former has just produced a gemma.

The axis (stipe plus rachis) of the stolonoid frond, which can reach a length of at least 45 cm (the normal fronds are 2–16 cm long), is dorsiventral, entirely green, and has a more or less distinct groove on the upper (adaxial) surface. In structure and width it is indistinguishable from the stipe of a normal frond.

Gemmae are produced alternately on the sides of the axis of the stolonoid frond and correspond in position to the pinnae of normal fronds, which are always alternate. Each gemma consists of a series of rhizome-type paleae inside which are root and frond primordia.

Several apparent anomalies in the development of stolonoid and normal fronds give further evidence of their homology. After producing several gemmae, a stolonoid frond may produce the terminal segment of a normal frond abruptly (*Fig. 1,* bottom left). Or an occasional pinna may be produced in place of a gemma. On the other hand, the rachis of a normal frond which has produced normal pinnae can, instead of producing a terminal segment, elongate and produce

Fig. 1. Plant of *Asplenium mannii* with soriferous fronds (on the right), a normal stolonoid frond (top left), and a stolonoid frond which has produced a terminal segment of a soriferous frond (bottom left). From *Faden & Holland 72/187* (EA). Fig. 2. Soriferous frond of *Asplenium mannii* which has become stolonoid at the apex. From *Pócs 6154/AQ* (EA).

gemmae (*Fig. 2*). The rachis then terminates in a crozier; it is clear that such fronds have become stolonoid.

Asplenium mannii has sometimes been placed in the genus *Loxoscaphe* or in *Asplenium* subg. *Loxoscaphe* (Tardieu-Blot, 1953, 1964). For the most part, however, the sori are asplenioid, and therefore *A. mannii* is a dareoid and not a loxoscaphoid *Asplenium*. The few loxoscaphoid sori which are sometimes present may be more indicative of the unsoundness of *Loxoscaphe* as a genus than of a close relationship between *A. mannii* and the loxoscaphoid *Asplenium* species. None of the continental African dareoid *Asplenium* species appear to be closely related to *A. mannii*, and its taxonomic relationships are uncertain.

Dimorphic fronds similar to those of *A. mannii* occur in only one other African species of *Asplenium*, *A. stoloniferum* Bory. As in *A. mannii*, the morphologically different fronds are soriferous and gemmiferous respectively. Although the latter are similar to the stolonoid fronds of *A. mannii* in lacking a lamina, they differ from them in two ways: they produce only one gemma, and the apex aborts soon after having produced it. Thus the gemmiferous fronds of *A. stoloniferum* have determinate growth and are usually more or less equal to the soriferous fronds in length. They produce a single new plant, unlike the stolonoid fronds of *A. mannii*. The soriferous fronds of *A. stoloniferum* differ from those of *A. mannii* in not being dareoid.

It is interesting to note that although the stolonoid fronds of *A. mannii* have been misunderstood, the similar fronds of *A. stoloniferum* were correctly interpreted by Sim (1915) who wrote, "Besides the ordinary fronds which are not proliferous, this species produces leafless fronds, which bend over and produce young plants at the apex."

ECOLOGY OF THE GEMMIFEROUS SPECIES

All of the East African gemmiferous species of *Asplenium* are plants of generally moist, evergreen forests. More than half of the species occur only in lowland and intermediate forests (up to 1800 m altitude in East Africa), but the following six are found commonly or exclusively in montane forests: *A. elliottii*, *A. protensum* and *A. bugoiense* (Group II), *A. monanthes* (Group III), *A. sandersonii* (Group IV), and *A. mannii* (Group V). From lists of pteridophytes occurring in several Kenya forests, it is observed that a higher percentage of the total number of *Asplenium* species are gemmiferous in intermediate (52%) than in montane (27–41%) forests. Additional data are required to confirm this generalization and to establish a pattern for lowland forests, which are uncommon in East Africa, and for which data are lacking.

Approximately seven-eighths of the East African representatives of the five groups are regularly or frequently terrestrial. All of the species in Groups I and III, and nearly all in Group II, are consistently terrestrial. Only *A. protensum* and perhaps *A. barteri*, both in Group II, are frequently epiphytic, and then no more than a few meters above the ground. In most species in these three groups the gemma is not brought in contact with the substrate during the normal growth

of the frond, but touches it only when the frond begins to droop and die. It is only then that a new plant is produced. There are some exceptions to this pattern. In *A. paucijugum* the fronds frequently arch sufficiently for the subterminal gemma to reach the ground. In plants of any species growing in constantly humid conditions such as spray zones of waterfalls, the gemmae begin to produce new plants even without touching the substrate.

The single East African representatives of Groups IV and V, *A. sandersonii* and *A. mannii* respectively, are regularly epiphytic, often high up on trees. Their habits of growth assure some or all of the gemmae rapid contact with the bark, and thus vegetative reproduction is fast and consistent. It would seem that these more highly specialized types of reproduction by gemmae are associated with the epiphytic habit, at least in East Africa. Such an adaptation would be particularly important to those species whose gametophytes had not become well-adapted to an epiphytic existence.

LITERATURE CITED

ALSTON, A. H. G. 1959. The ferns and fern-allies of West Tropical Africa. Suppl. to 2nd ed., Flora of West Tropical Africa. Crown Agents, London.

SCHELPE, E. A. C. L. E. 1969. A revised check-list of the Pteridophyta of southern Africa. J. So. Afr. Bot. **35**(2): 127–140.

———. 1970. Pteridophyta *in* Flora Zambesiaca, ed. A. W. Exell and E. Launert. Crown Agents, London.

SIM, T. R. 1915. The ferns of South Africa, 2nd ed. Cambridge University Press, Cambridge.

TARDIEU-BLOT, M.-L. 1953. Les Ptéridophytes de l'Afrique Intertropicale Française. Mém. Inst. Fr. Afr. Noire **28**: 1–241.

———. 1958. Polypodiacées (sensu lato). Part I *in* Flore de Madagascar et des Comores, ed. H. Humbert. Firmin-Didot, Paris.

———. 1964. Ptéridophytes *in* Flore du Cameroun, ed. A. Aubréville. Muséum National d'Histoire Naturelle, Paris.

The Genus Lindsaea in Fiji

G. BROWNLIE*

The genus *Lindsaea* has already been dealt with in detail for the Pacific Islands and the Malesian region in two papers by Kramer (1970, 1971). The present paper records additional information in the form of new records and site conditions for the Fiji group.

Field observation has shown that many species of *Lindsaea,* both terrestrial and epiphytic, can be used as indicators of drainage patterns in the lowland rain forest in Fiji. The terrestrial species change over a very short area, but each apparently always occupies identical, restricted parts of any slope. In the epiphytic species this is reflected in the distance above ground where each grows. An example of the simplest case is shown in lowland rain-forest of southeastern Viti Levu, where the crests normally carry *L. pulchra;* a short distance down each side this is replaced by *L. pacifica* or *L. harveyi;* and in the wettest ground near streams *L. lapeyrousii* occurs. The most widespread epiphytic species, *L. vitiensis, L. repens,* and *L. pickeringii,* occur on fallen, decaying logs on the crests and increasingly higher up tree trunks as one descends the slope. If the canopy above the crest is broken for a lengthy period, *L. pulchra* is replaced by *L. ensifolia* as drying out progresses. Where extensive areas of nearly level ground are found under the same conditions, the genus appears to be completely absent.

Specimens listed are in addition to those given by Kramer (1971). SUVA represents specimens held in the Herbarium of the Fiji Department of Agriculture; these are listed with accession numbers only. Collections made by the author are at present in his personal herbarium.

Distribution for the two large islands is listed under the different provincial districts. For details on these and for the various regional climatic zones mentioned, reference can be made to Derrick (1955).

Synonyms and references listed under the individual species are limited as far as possible to those publications dealing entirely or largely with Fiji. Full details are given in Kramer (1970, 1971).

KEY TO THE SPECIES

1. Rhizome short-creeping; plants always terrestrial.
   2. Lamina bipinnate or more compound, the terminal pinna unlike the lateral ones.
      3. Veins free.....1. *L. moorei*
      3. Veins anastomosing.....2. *L. ensifolia* subsp. *agatii*
   2. Lamina simply pinnate or, if bipinnate, the terminal pinna similar to the lateral ones.
      4. Veins free.
         5. Pinnae not dimidiate.....3. *L. gueriniana*
         5. Pinnae (or segments) dimidiate.
            6. Lamina simply pinnate; pinnae deeply incised....4. *L. lapeyroussii* subsp. *vitiensis*
            6. Lamina bipinnate; segments deeply incised.....5. *L. tetragona*
      4. Veins anastomosing.

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of the frond, but touches it only when the frond begins to droop and die. It is only then that a new plant is produced. There are some exceptions to this pattern. In *A. paucijugum* the fronds frequently arch sufficiently for the subterminal gemma to reach the ground. In plants of any species growing in constantly humid conditions such as spray zones of waterfalls, the gemmae begin to produce new plants even without touching the substrate.

The single East African representatives of Groups IV and V, *A. sandersonii* and *A. mannii* respectively, are regularly epiphytic, often high up on trees. Their habits of growth assure some or all of the gemmae rapid contact with the bark, and thus vegetative reproduction is fast and consistent. It would seem that these more highly specialized types of reproduction by gemmae are associated with the epiphytic habit, at least in East Africa. Such an adaptation would be particularly important to those species whose gametophytes had not become well-adapted to an epiphytic existence.

LITERATURE CITED

ALSTON, A. H. G. 1959. The ferns and fern-allies of West Tropical Africa. Suppl. to 2nd ed., Flora of West Tropical Africa. Crown Agents, London.

SCHELPE, E. A. C. L. E. 1969. A revised check-list of the Pteridophyta of southern Africa. J. So. Afr. Bot. **35**(2): 127–140.

———. 1970. Pteridophyta *in* Flora Zambesiaca, ed. A. W. Exell and E. Launert. Crown Agents, London.

SIM, T. R. 1915. The ferns of South Africa, 2nd ed. Cambridge University Press, Cambridge.

TARDIEU-BLOT, M.-L. 1953. Les Ptéridophytes de l'Afrique Intertropicale Française. Mém. Inst. Fr. Afr. Noire **28**: 1–241.

———. 1958. Polypodiacées (sensu lato). Part I *in* Flore de Madagascar et des Comores, ed. H. Humbert. Firmin-Didot, Paris.

———. 1964. Ptéridophytes *in* Flore du Cameroun, ed. A. Aubréville. Muséum National d'Histoire Naturelle, Paris.

dominantly simply pinnate, sometimes subbipinnate or even fully bipinnate, with 8–15 pinnae on each side; pinnae lanceolate, sessile or short-stalked, 5–10 cm long, 4–8 mm wide; lateral segments of pinnatifid pinnae obovate to lanceolate, decurrent, the terminal one long, undivided. Upper primary pinnae gradually and strongly reduced. Margins of sterile segments finely serrate. Veins forming a series of narrow areolae along each side of the costa. Sori continuous except in the incisions of the lobes.

Also cited by Kramer (1970, p. 170).

Widespread throughout the dry zones of the main islands of Fiji, being one of the most common ferns of the talasiga soils. It also occurs on well-drained ridges in high-rainfall areas where the vegetation has been cleared and the ground exposed to continuous direct sunlight.

SPECIMENS EXAMINED:

VITI LEVU: Ba: *Brownlie 872, 1227, 1233, 1951;* SUVA *13505.* **Naitasiri:** *Brownlie 1125.* **Rewa:** *Brownlie 1294.*

VANUA LEVU: Cakaudrove: *Brownlie 1463, 1502.* **Macuata:** *Brownlie 810.*

3. Lindsaea gueriniana (Gaud.) Desv. Mém. Soc. Linn. Paris 6: 312. 1827.

Schizoloma guerinianum Gaud. Ann. Sci. Nat. Paris **3:** 508. 1824.

Rhizome moderately long-creeping, clothed with reddish-brown, acicular scales. Stipes close together, 5–20 cm long, reddish-brown to almost black. Lamina linear in outline, to 30 cm × 3 cm, simply pinnate, with up to 20 pinnae on each side; lower pinnae remote, most of the others about half their width apart, the upper ones gradually reduced; terminal segment small, lanceolate; largest pinnae 7–15 mm × 3–7 mm, almost ovate, broadly rounded, the acroscopic side of the base sometimes with a distinct auricle. Veins obscure, once- or twice-forked, free. Sori continuous, except along the base of the lower margin, and sometimes absent at the pinna apex; indusium entire, reaching the margin.

Also cited by Kramer (1970, p. 178).

Recorded from Fiji for the first time, occurring in a very restricted area on a steep, partially exposed slope, facing southeast, at about 400 m near the summit of Mt. Korobaba in southeastern Viti Levu, in association with *L. moorei.*

SPECIMENS EXAMINED:

VITI LEVU: Rewa: *Brownlie 1056, 1295.*

4. Lindsaea lapeyrousii subsp. vitiensis Kramer, Blumea 18: 179. 1970.

Davallia hymenophylloides Baker, J. Bot. Brit. & For. **17:** 294. 1879, *nec* (Blume) Baker, 1867, *nec* (Blume) Kuhn, 1869.

Rhizome very short-creeping; scales short, reddish-brown, soon lost. Stipes close together, ca 2 cm long, dark at the base, stramineous upwards. Lamina 15–40 cm × 2–4 cm, linear, very gradually tapering towards the base, widest near the middle, simply pinnate, the lower pinnae more widely spaced and much reduced, the upper reduced to a pinnatifid frond apex; the largest pinnae 12 mm × 4 mm, deeply incised from the upper margin, with 5–8 oblique, linear segments. Veins simple. Sori usually on 1 vein ending, rarely on 2; indusium pale, almost reaching the margin.

This subspecies is endemic to Fiji. It is found in lowland rain forest of the two main islands, where it occurs on stream banks or at the bases of very wet slopes, always in the deepest shade.

SPECIMENS EXAMINED:

VITI LEVU: Naitasiri: *Brownlie 764, 1165, 1940, 2020.* **Namosi:** *Brownlie 1557, 1575, 2095.* **Rewa:** *Brownlie 1686, 1918.*

5. Lindsaea tetragona Kramer, Blumea 15: 564. 1967.

Lindsaea tenuifolia sensu Copel. Bishop Mus. Bull. **59:** 73. 1929 *et sensu* Parham, Plants Fiji Isls. 13. 1964, *non* Blume, 1828.

Rhizome short-creeping with yellowish-brown, triangular scales. Stipes close, stramineous, sulcate, to 30 cm long. Fronds 15–40 cm long, bipinnate, with 3–9 pairs of lateral pinnae and a similar terminal one; pinnae sessile, oblique, up to 15 × 2.5 cm; upper margins of pinnules incised to ½–⅔ of the depth, the lobes linear; upper pinnules strongly reduced and confluent in the pinna apex. Color rather light green. Veins evident, usually only one to each lobe. Indusium not quite reaching the margin, pale, sinuate or entire, strongly reflexed when mature.

Also cited by Kramer (1970, p. 171).

Terrestrial in lowland forest of high rainfall areas of Viti Levu and Vanua Levu, in shady but fairly well-drained sites. Nowhere very common, usually only 2 or 3 plants being found in any one area.

SPECIMENS EXAMINED:

VITI LEVU: Rewa: *Brownlie 1547.* **VANUA LEVU: Cakaudrove:** *Brownlie 1417.*

6. Lindsaea pacifica Kramer, Blumea 18: 173. 1970.

Lindsaea seemannii Carr. ex Seem. Fl. Vit. 338. 1873, *non* J. Smith, 1854.

Lindsaea decomposita sensu Copel. Bishop Mus. Bull. **59:** 72. 1929, *sensu* C. H. Wright, Kew Bull. **1930:** 345. 1930, *et sensu* Parham, Plants Fiji Isls. 12. 1964, *omnes pro parte, non* Willd. 1810.

Rhizome short-creeping, with reddish-brown, narrowly triangular scales. Stipes clustered, 10–40 cm long, stramineous or light brown. Lamina 15–30 cm long, bipinnate, with 3–6 pinnae on each side, and a similar terminal one; pinnae sharply ascending, the largest 20 × 2.5 cm, strongly tapering to a caudate apex; terminal pinna commonly the largest. Pinnules 20–35 pairs, mostly subcontiguous, 7–12 mm × 3–5 mm, the lower margin straight, the upper margin convex, narrowed from the base; upper pinnules very gradually and strongly reduced, the uppermost minute and confluent with the caudate apex. Margins of segments with up to 3 shallow, oblique incisions often not reaching the level of the receptacle. Veins inconspicuous, regularly anastomosing. Sori interrupted, on 2–6 vein-endings; indusium subentire, falling short of the margin.

Possibly the most common terrestrial species in wet forest from sea-level to 1000 m. Absent in better-drained mountain forest into which the related *L. harveyi* extends.

SPECIMENS EXAMINED:

VITI LEVU: Ba: *Brownlie 1811.* **Naitasiri:** *Brownlie 552, 979, 1308, 1712;* SUVA *18104, 18126, 18163.* **Namosi:** *Brownlie 1558, 2106.* **Rewa:** *Brownlie 1176, 1539, 1680.* **Serua:** *Brownlie 2117; Webster & Hildreth 14331* (DAV).

VANUA LEVU: Bua: SUVA *18178.* **Cakaudrove:** *Brownlie 1447.* **KADAVU:** SUVA *125.* **OVALAU:** *Brownlie 1662.* **TAVEUNI:** *Brownlie 989, 1347;* SUVA *16011.*

7. Lindsaea propinqua Hooker, Nightingale's Oceanic Sketches 130. 1835.

Rhizome short-creeping, with narrowly triangular, castaneous scales. Stipes to 60 cm long, stramineous with a darker base. Lamina 20–35 cm long, bipinnate with 2–6 pinnae on each side and a similar terminal one; pinnae sessile, lanceolate,

10–20 × 2–5 cm; pinnules up to 25 on each side, subcontiguous, 10–30 × 5–10 mm, only slightly narrowed towards the apex; upper margin with 2 or 3 oblique incisions, sometimes one on the outer margin also; upper pinnules very little reduced, asymmetric, almost free. Veins anastomosing. Sori usually on 2–4 vein endings; indusium pale, entire, almost reaching the margin.

Ascribed to Fiji on the basis of two early collections only; not recorded during the present century. As this is predominantly a species of Central and Eastern Polynesia, and as it has not been recorded in recent years, the authenticity of the localities in the earlier collections is open to some doubt.

8. Lindsaea obtusa J. Smith in Hooker, Sp. Fil. 1: 224. 1846.

Rhizome short-creeping, with narrowly-triangular brown scales. Stipes less than 1 cm apart, dark brown to almost black, 10–15 cm long. Lamina mostly simply pinnate, occasionally bipinnate with 1 or 2 pairs of lateral pinnae and a similar terminal one; simply pinnate fronds to 15 × 2.2 cm; segments slightly chartaceous, dark green, ascending, close but not contiguous, ligulate to almost trapeziform, to 10 × 4 mm, the apex broadly rounded; upper and outer margins with up to 5 oblique incisions, margins of lobes erose. Veins regularly anastomosing, forming 1 or 2 series of areolae. Sori variable in length, usually on at least 2 vein-endings; indusium not reaching the margin.

Also cited by Kramer (1970, p. 171).

Not previously recorded from Fiji, and there collected only once, terrestrial in mountain forest above Somosomo village on Taveuni. Very difficult to distinguish from small forms of *L. harveyi,* from which it most clearly differs in the very dark coloring of the living and dried plants. The above description is from the Fijian specimens.

SPECIMENS EXAMINED:

TAVEUNI: *Brownlie 1322.*

9. Lindsaea harveyi Carr. ex Seem. Fl. Vit. 338. 1873.

Lindsaea decomposita sensu Copel. Bishop Mus. Bull. **59:** 72. 1929, *et sensu* Parham, Plants Fiji Isls. 12. 1964, *duo pro parte,* non Willd., 1810.

Rhizome short-creeping, clothed with reddish-brown, narrowly triangular scales. Stipes close together, 10–50 cm long, stramineous with a darker base in small specimens, brown to reddish-brown in very large ones. Fronds bipinnate, occasionally subtripinnate, 10–50 cm long, rarely simply pinnate; pinnae 1–5 to each side, and a similar terminal one, 5–20 cm × 2–3 cm, ascending, acuminate; pinnules mostly almost contiguous, subrectangular, little narrowed from the base to the rounded apex, the upper margin slightly convex and with 4–6 incisions reaching below the level of the receptacle; upper pinnules rather abruptly reduced. Veins regularly anastomosing. Sori 1 to each lobe, on 2–4 vein-endings; indusium pale brown, falling short of the margin.

Also cited by Kramer (1970, p. 172).

Terrestrial in forest from near sea-level to 800 m, in high-rainfall areas and in mountain forest of the intermediate zone. In southeastern Viti Levu small forms occur frequently with *L. pacifica.* The largest specimens, however, are found on better drained slopes and in forest of the intermediate zone where *L. pacifica* is absent.

SPECIMENS EXAMINED:

VITI LEVU: Ba: *Brownlie 1237, 1240, 1255, 1264.* **Naitasiri:** *Brownlie 977, 978, 1143, 1144.*

1152; SUVA *1510.* **Namosi:** *Brownlie 2072.* **Rewa:** *Brownlie 1180.* **Tailevu:** SUVA *1024.*
VANUA LEVU: Bua: SUVA *18173.* **Cakaudrove:** *Brownlie 1461.*
OVALAU: *Brownlie 1640.*

10. Lindsaea rigida J. Smith in Hooker, Sp. Fil. 1: 217, t. 63. 1846.

Rhizome long-creeping, clothed with brown, narrowly triangular scales. Stipes 2.5 cm apart, olive to dark brown. Lamina oblong in outline, 15–30 cm long, bipinnate, with 1–5 pairs of pinnae and a similar terminal one; pinnae ascending, linear, 5–15 cm × 1–2 cm, gradually tapering from just below the middle to the apex; pinnules coriaceous, very dark olivaceous-green when dry, not contiguous, twice as long as wide, mostly obliquely ovate; lower margin straight, upper margin somewhat convex, crenate to dentate in sterile pinnae, crenately lobed in fertile ones. Veins free or irregularly anastomosing. Sori on the outer lobes, on 2–5 veins; indusium rigid, brownish.

Also cited by Kramer (1970, p. 184).

Not previously recorded from Fiji, and apparently very localized, having been observed on a few trees at ca 1200 m on Mt. Tomaniivi, always exposed to full sunlight.

SPECIMENS EXAMINED:
VITI LEVU: Ba: *Brownlie 901, 1763.*

11. Lindsaea pickeringii (Brackenr.) Mett. ex Kuhn, Linnaea 36: 81. 1869.

Synaphlebium pickeringii Branckenr. U. S. Expl. Exped. **16:** 223, *t. 30, f. 2.* 1854.

Rhizome long-creeping, castaneous, usually scaleless and polished when mature, or scaly near the stipe-bases; scales lanceolate, bright honey-colored. Stipes to 5 cm apart, light, reddish-brown, often darker at the base. Lamina 15–38 × 2–3.5 cm, simply pinnate; pinnae slightly ascending, distinctly separate or contiguous, more remote towards the base, elongate-triangular, narrowed from base to apex, 1–1.5 cm × 3–5 cm, the upper ones gradually reduced to a pinnatifid frond apex; lower margin straight, the upper with 3–5 oblique incisions. Veins immersed, free or anastomosing to form a single series of areolae. Sori on 1–3 vein endings; indusium pale, not reaching the margin.

Also cited by Carruthers in Seemann (1873, p. 337), Copeland (1929, p. 71), Parham (1964, p. 13), and Kramer (1970, p. 190).

Occurs in rain forest from ca 350–800 m, as a low epiphyte on tree trunks, in similar sites to *L. vitiensis;* most common on Vanua Levu and Taveuni. Confusion can occur in differentiating it from extreme forms of *L. pulchra* var. *protracta,* as this form tends to have the vein anastomoses reduced in number, and has similar oblique incisions of the pinnae. This confusion is most apparent where both occur in the same area with typical *L. pulchra* absent, as on Mt. Nakobalevu in southeastern Viti Levu.

SPECIMENS EXAMINED:
VITI LEVU: Naitasiri: *Brownlie 1697.* **TAVEUNI:** *Brownlie 996, 1337;* SUVA *12412.*

12a. Lindsaea pulchra (Brackenr.) Carr. ex Seem. Fl. Vit. 337. 1873, var. pulchra.

Rhizome long-creeping, clothed with reddish-brown, narrowly triangular, acuminate scales. Stipes to 5 cm apart, stramineous or pale brown with a dark base, occasionally dark-colored throughout, 3–17 cm long. Lamina narrowly oblong to lanceolate, 10–30 × 3–6 cm, simply pinnate with up to 40 pinnae on each side; lower pinnae somewhat remote, the remainder close but not contiguous,

parallelogram-shaped, little or not at all narrowed toward the apex, the lower edge convex, the upper edge straight or convex with 3–5 oblique incisions 1.5–3 mm deep, the other edge sometimes with a single incision; lobes rounded to truncate; upper pinnae abruptly reduced. Texture slightly chartaceous. Veins once or twice forked, regularly anastomosing. Sori one to each lobe, on 2–4 vein-endings; indusium delicate, not reaching the margin.

Also cited by Copeland (1929, p. 72), Parham (1964, p. 13), and Kramer (1970, p. 184, excluding *L. protracta*).

Common in the wet zones of the main islands, creeping on the ground on well-drained ridges inside forest, rarely climbing a few centimeters up tree-trunks. Less common in intermediate zone forest 100–1000 m.

SPECIMENS EXAMINED:

VITI LEVU: Ba: *Brownlie 894, 1243, 1246a, 1254, 1727, 1729.* **Naitasiri:** *Brownlie 581.* **Namosi:** *Brownlie 2088.* **Rewa:** *Brownlie 1049, 1178, 1542, 1683.*
OVALAU: *Brownlie 1636.* **TAVEUNI:** SUVA *16006.*

12b. Lindsaea pulchra var. protracta (Copel.) Brownlie, comb. & stat. nov.

Lindsaea protracta Copel. Bishop Mus. Bull. **59:** 14, *t. 3.* 1929.

Differs from var. *pulchra* in the shape of the pinnae, which are markedly narrowed towards the apex with an elongate distal lobe, with up to 8 major incisions and several secondary ones to each pinna, and with 1–3 incisions on the outer, rounded edge.

Also cited by Parham (1964, p. 13).

Apparently restricted to median and higher altitudes in mountain forests from southeastern Viti Levu to the vicinity of Mt. Tomaniivi. Although somewhat variable in the degree of protraction of the pinnae, this appears to be worthy of varietal rank in view of the frequency of occurrence and its altitudinal restriction.

SPECIMENS EXAMINED:

VITI LEVU: Ba: *Brownlie 1859.* **Naitasiri:** *Brownlie 1709.* **Namosi:** SUVA *20102.* **Rewa:** *Brownlie 1050, 1179, 1684, 1685, 1915.*

13a. Lindsaea repens var. sessilis (Copel.) Kramer, Blumea 15: 568. 1968.

Lindsaea sessilis Copel. Phil. J. Sci. Bot. **6:** 82. 1911.

Rhizome long-creeping, with narrowly triangular to lanceolate scales. Stipes to 4.5 cm long, stramineous to pale brown, the base darker. Lamina linear, simply pinnate, narrowed to both ends, 25–60 × 2–5.5 cm; pinnae numerous, elongate-triangular, sometimes slightly falcate, the lower often slightly falcately decurved, the basal pinnae reduced, the upper ones reduced to a pinnatifid apex, the median pinnae 2–2.5 cm × 4–8 mm, the upper margin shallowly incised, the incisions reaching to at least the level of the receptacle, the lobes rounded. Juvenile fronds with deeply dissected pinnae. Sori on 1 or rarely 2 vein endings, indusium round with a concave base.

Also cited by Kramer (1970, p. 180).

SPECIMENS EXAMINED:

VITI LEVU: Naitasiri: *Brownlie 2021.* **Namosi:** *Brownlie 2105.* **Rewa:** *Brownlie 1112, 1689, 1921.* **VANUA LEVU: Cakaudrove:** *Brownlie 1441, 1491.*

13b. Lindsaea repens var. marquesensis E. Brown, Bishop Mus. Bull. 89: 51, t. 9. 1931.

Rhizome long-creeping, with narrowly triangular to lanceolate scales. Stipes

2–5 cm long, stramineous to pale brown, the base darker. Lamina linear, simply pinnate, narrowed to both ends, similar in size to var. *sessilis;* pinnae numerous, elongate-triangular, sometimes slightly falcate, the upper ones reduced to a pinnatifid apex, the upper margin shallowly incised, the incisions reaching to about the level of the receptacle, the outer lobes very oblique. Juvenile fronds with deeply dissected pinnae. Sori on 1 or 2 vein endings; indusium with an almost straight base.

Also cited by Kramer (1970, p. 182).

Confined to lowland rain forest, epiphytic, usually some distance above the ground on tree trunks, less frequently on fallen rotting logs on ridges.

14. Lindsaea vitiensis Kramer, Blumea 18: 191. 1970.

Lindsaea adiantoides sensu Copel. Bishop Mus. Bull. **59:** 71. 1929, *et sensu* Parham, Plants Fiji Isls. 12. 1964, *non* (Blume) Kuhn, 1869.

Rhizome long-creeping, wiry, shiny when old, the younger part clothed with narrowly lanceolate, light brown scales. Stipes remote, wiry, to 8 cm long. Lamina simply pinnate, linear, to 20 × 2.5 cm, with up to 30 pinnae on each side; lower pinnae somewhat remote, the median almost contiguous, the uppermost abruptly reduced to a lobed frond apex; largest pinnae 12 × 5 mm, rounded-narrowed from base to apex, the upper margin incised. Veins free, single or once-forked. Sori single, in the lobes on 1 or 2 vein endings; indusium pale, sinuate, basally attached, almost or quite reaching the margin.

Widely distributed throughout high-rainfall forest of the main islands from near sea-level upwards, and in mountain forest of the intermediate zone up to 1300 m. Epiphytic on the lower parts of tree trunks and on fallen logs. Usually in somewhat wetter sites than *L. pulchra,* and when growing on trees closer to the ground than *L. repens.*

SPECIMENS EXAMINED:

VITI LEVU: Ba: *Brownlie 883 1769.* **Naitasiri:** *Brownlie 1118, 1151, 1281, 1698, 1933, 1941;* SUVA *18127.* **Namosi:** *SUVA 1773, 1940.* **Rewa:** *Brownlie 1540, 1682, 1699;* SUVA *1164.*
VANUA LEVU: Bua: SUVA *18181.* **Macuata:** *Brownlie 803, 804.*
TAVEUNI: *Brownlie 992, 1348.*

LITERATURE CITED

BAKER, J. G. 1879. On a collection of ferns gathered in the Fiji Islands by Mr. John Horne F.R.S. J. Bot. Brit. & For. **17:** 292–300.

BRACKENRIDGE, W. D. 1854. Filices *in* C. Wilkes, U. S. Exploring Expedition, vol. 16.

CARRUTHERS, W. 1873. An enumeration of the ferns collected by Dr. Seemann in Fiji *in* B. Seemann, Flora Vitiensis. London.

COPELAND, E. B. 1929. Ferns of Fiji. Bernice P. Bishop Mus. Bull. **59:** 1–105.

DERRICK, R. A. 1955. The Fiji Islands—A geographical Handbook, rev. ed. Suva.

KRAMER, K. U. 1967a. The Lindsaeoid ferns of the Old World—1. New Caledonia. Acta Bot. Neerl. **15:** 562–584.

———. 1967b. The Lindsaeoid ferns of the Old World—3. Notes on Lindsaea and Sphenomeris in the Flora Malesiana area. Blumea **15:** 557–574.

———. 1970. The Lindsaeoid ferns of the Old World—5. The smaller Pacific islands. Blumea **18:** 157–194.

———. 1971. Lindsaea-group. Fl. Males. II, 1(3): 177–254.

PARHAM, J. W. 1964. Plants of the Fiji Islands. Suva. [The 2nd edition (1972) follows the terminology of Kramer (1970).]

WRIGHT, C. H. 1930. Ferns collected in Fiji by Sir Everard im Thurn, K.C.M.G. Kew Bull. **1930:** 343–348. 1930.

Reticulation of Holly Ferns (Polystichum) in the Western United States and Adjacent Canada[1]

W. H. WAGNER, JR.*

Coming from Fresno and growing up in California, the late Conrad V. Morton always had a special interest in western American ferns. He returned frequently to the state of his birth, and often made field trips. He wrote me as follows of his observations on western Holly Ferns[2] (letter, 21 March 1960): "When I was in California in 1951, I did a little collecting in the Santa Lucia Mountains. The observations that I made seemed to show that *Polystichum californicum* was truly the hybrid *P. dudleyi* × *munitum*. . . .You may find a few specimens that seem to show backcrossing with *munitum*."

That was the first statement I received from anyone that intimated that hybridization might be involved in the origin of the well known fern *P. californicum*. Although hybrids are well known to occur in the genus, both in eastern North America and Eurasia, practically all of the specimens considered to be hybrids up to 1960 were found to be sterile. Morton's suggestion was not only that a widespread western Holly Fern was a hybrid, but also *that it could backcross*. In other words, it was fertile.

The knowledge of cytogenetic conditions in our North American Holly Ferns lags behind the European, where workers such as Irene Manton, D. E. Meyer, Anne Sleep, and T. Reichstein have carried out significant research. Some of their more important contributions are given in the bibliography below. Vida (1972) points out that "Every possible hybrid combination has been found and most of these have been synthesized between the four European species." Until recently, the two best-known examples of hybrids in the temperate New World have been *P. acrostichoides* × *braunii* (Thompson & Coffin, 1940) and *P. acrostichoides* × *lonchitis* (Wagner & Hagenah, 1954), both crosses from the eastern United States. Neither of these has been studied cytologically in detail, although Morzenti (1962) reported tetraploidy—still unexplained—in *P. acrostichoides* ($n = 41$) × *braunii* ($n = 82$); and Wagner and Chen (*in* Löve & Solbrig, 1964) reported irregular meiosis in *P. acrostichoides* × *lonchitis*, without, however, indicating the amount of pair formation. Except for preliminary reports by the

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[1] I am indebted to Katherine Lim Chen, D. L. Branscomb, Joseph Ewan, T. M. C. Taylor, A. R. Kruckeberg, John C. Reeder, and Florence S. Wagner for their help in various ways. The staffs of the following herbaria kindly sent specimens on loan: U. S. National Herbarium, University of California (Berkeley), University of Washington, University of British Columbia, and Yale University. Research initiated under National Science Foundation Project G–10846 and completed under NSF GB–30918x, "The Evolutionary Characters of the Ferns."

[2] Unless there is already another well known English name, I here designate all of the polystichums as Holly Ferns rather than as Shield Ferns because of the widespread confusion of the latter common name with the members of the genus *Dryopteris*.

RR
AAR
AAAA
DR
DD
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writer (Wagner, 1963, 1966), knowledge of the chromosomes of western *Polystichum* hybrids has been lacking up to now.

My field and herbarium studies have extended over a decade, including major field trips in 1961, 1963, 1969, and 1973. Seven new sterile hybrids were discovered. The present paper contains numerous new cytological reports for which the herbarium vouchers (designated in the legends of the figures), chromosome photographs, and permanent microscope slides are preserved at the University of Michigan, Ann Arbor.

Ewan (1942, 1944) was one of the first to grapple with the problems of western Holly Ferns. Variation of some of them was so confusing that taxonomic treatments differed widely. The bipinnate forms were especially troublesome, and such floras as Jepson's (1923) differed from those, for example, of Abrams (1940) and Munz (1959) in their handling of *P. californicum*. Jepson regarded it as a variety of *P. aculeatum* (L.) Roth, the typical variety of which is European (Alston, 1940). The other authors—as well as more recent ones such as Hitchcock et al. (1969) and Cronquist et al. (1972)—upheld *P. californicum* as a distinct species. The initial, detailed cytological investigations of *P. californicum* were those by the author (Wagner, 1963). These suggested that this fern was actually a hybrid but that it exists in both fertile and sterile forms. The parents proposed were *P. dudleyi* and *P. munitum*, just as Morton had suggested. Later, a new species was described from the Northwest (Wagner, 1966) and named *P. kruckebergii*. This was interpreted also as a hybrid, in this case *P. lonchitis* × *mohrioides*. By this stage in our research, evidence was rapidly accumulating that the very familiar Crag Holly Fern, *P. scopulinum*, was also a hybrid, this one involving *P. mohrioides* and *P. munitum*, bringing to three the known number of fertile derivative hybrid taxa. For convenience in later discussion, all of the taxa now known will be listed here. Those which appear to be basic species are given letter symbols that will be used throughout this paper. Fertile taxa include *P. andersonii* Hopkins (AAAA), *P. californicum* (D. C. Eaton) Underw., *P. kruckebergii* Wagner, *P. dudleyi* Maxon (DD), *P. lonchitis* (L.) Roth (LL), *P. mohrioides* (Bory) Presl (syn. *P. lemmonii* Underw.) (MM), *P. munitum* (Kaulf.) Presl (RR), and *P. scopulinum* (D. C. Eaton) Maxon. The sterile taxa are *P. andersonii* × *munitum*, *P. californicum* × *dudleyi*, *P. californicum* × *munitum*, *P. dudleyi* × *munitum*, *P. mohrioides* × *munitum*, *P. mohrioides* × *scopulinum*, and *P. munitum* × *scopulinum*. The total now known in the western United States in this group is 15 taxa, fertile and sterile. As will be discussed further, however, two of the sterile ones are indistinguishable without

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Fig. 1. Fronds of *Polystichum*. AAAA = *P. andersonii*, Snohomish Co., Washington, *63116–6*. AAR = *P. andersonii* × *munitum*, same locality, *63115–10*. DD = *P. dudley*, Napa Co., California, *E–3*. DDRR = *P. californicum* (4*x*), same locality, *C–33*. DR = *P. californicum* (2*x*), same locality, *C–42*. DDR = *P. californicum* × *dudleyi*, same locality, *D–11*. DRR = *P. californicum* × *munitum*, same locality, *A–4*. RR = *P. munitum*, Snohomish Co., Washington, *63114–1*. Collections at MICH, by Wagner.

microscopic examination or germination experiments from two of the fertile ones. These are *P. dudleyi* × *munitum* (2*x*) and *P. californicum* (4*x*), and *P. mohrioides* × *munitum* (2*x*) and *P. scopulinum* (4*x*). Evidence for these interpretations is presented below.

Fig. 2. Ranges of *Polystichum* in the western United States.

Because of the generally excellent descriptions and illustrations available in modern floras, e.g., Cronquist et al. (1972), Hitchcock et al. (1969), and Taylor (1970), it will not be necessary to redescribe the well known basic taxa. The reader is referred to these works for this information. Here we shall discuss the taxa in the light of our studies of geographical distribution, field occurrence, pinna structure, epidermal patterns, spore form and size, and chromosomes.

THE BASIC SPECIES

Those taxa which represent extremes in the variation (i.e., do not occupy intermediate positions between the others) are referred to as basic species. With one exception, all of these are diploid. All are fertile and their spores are normal in morphology and germination.

Polystichum munitum.—The Western Sword Fern is by far the most abundant and wide-ranging of the basic species. Usually its fronds are over 6 dm long. It has many forms and probably contains distinct varieties or subspecies. The over-all range is shown in comparison with other "members of the Redwood community," the Redwood itself, *Sequoia sempervirens,* and the Sorrel, *Oxalis oregana,* by Raven and Curtis (1970).

Polystichum lonchitis.—Closely related to *P. munitum* is the Northern Holly Fern, which usually has fronds averaging only 2–4 dm long. It extends around the world at the higher latitudes. In the United States it occurs at higher altitudes in the mountains. In western North America where *P. lonchitis* and *P. munitum* occur together in the same communities, certain plants are problematic and suggest that some form of introgression may actually be occurring between them. Typically, however, *P. lonchitis* has relatively short pinnae (compare *Fig. 3,* LL with RR) and its stipe is very short, with the basal pinnae reduced to small, triangular auricles. The distribution of *P. lonchitis* is shown in *Fig. 2;* Taylor (1970) shows its further range to the north in the Pacific Northwest up to the Gulf of Alaska.

Polystichum dudleyi.—In contrast to *P. munitum* and *P. lonchitis,* the other three basic species are bipinnate. Dudley's Holly Fern is a fairly rare species limited to a narrow area of coastal California (*Fig. 2*). This species closely resembles the Hawaiian *P. haleakalense* and may prove to be conspecific with it. The fronds average 6.5 (4–10) dm long; the pinnae are delicate and are provided with numerous, soft, narrow, pale scales. The venation pattern is strikingly different from those of *P. munitum* and *P. lonchitis* (*Fig. 3*), as well as from *P. andersonii* and *P. mohrioides.*

Polystichum mohrioides.—The Shasta Holly Fern, *P. mohrioides,* is confined to high mountains in the southern part of its North American range, but grows at lower altitudes in the north. It is a well known amphitropical species (Raven, 1963). Like *P. dudleyi, P. mohrioides* is a rare fern, occurring sporadically from northern California (*Fig. 2*) to southern British Columbia (Taylor, 1970, p. 181). It occurs on cliffs or talus of ultramafic rock (Kruckeberg, 1964). The illustration by Munz (1940, p. 10) is especially good. This is generally a small fern with leaves less than 3 dm long; the pinnules are rounded and conspicuously overlapping. The rather blunt segment tips are unique in this group. At the anatomical level, *P. mohrioides* is also very distinctive. The veins are very close (*Fig. 2,* MM), the lower epidermis has unusually large cells (*Fig. 4*), and both epidermal surfaces consistently show numerous unicellular glands. Such glands are less common or absent in *P. dudleyi,* and were never observed in those collections of the other basic species which we examined. Also, the spores of

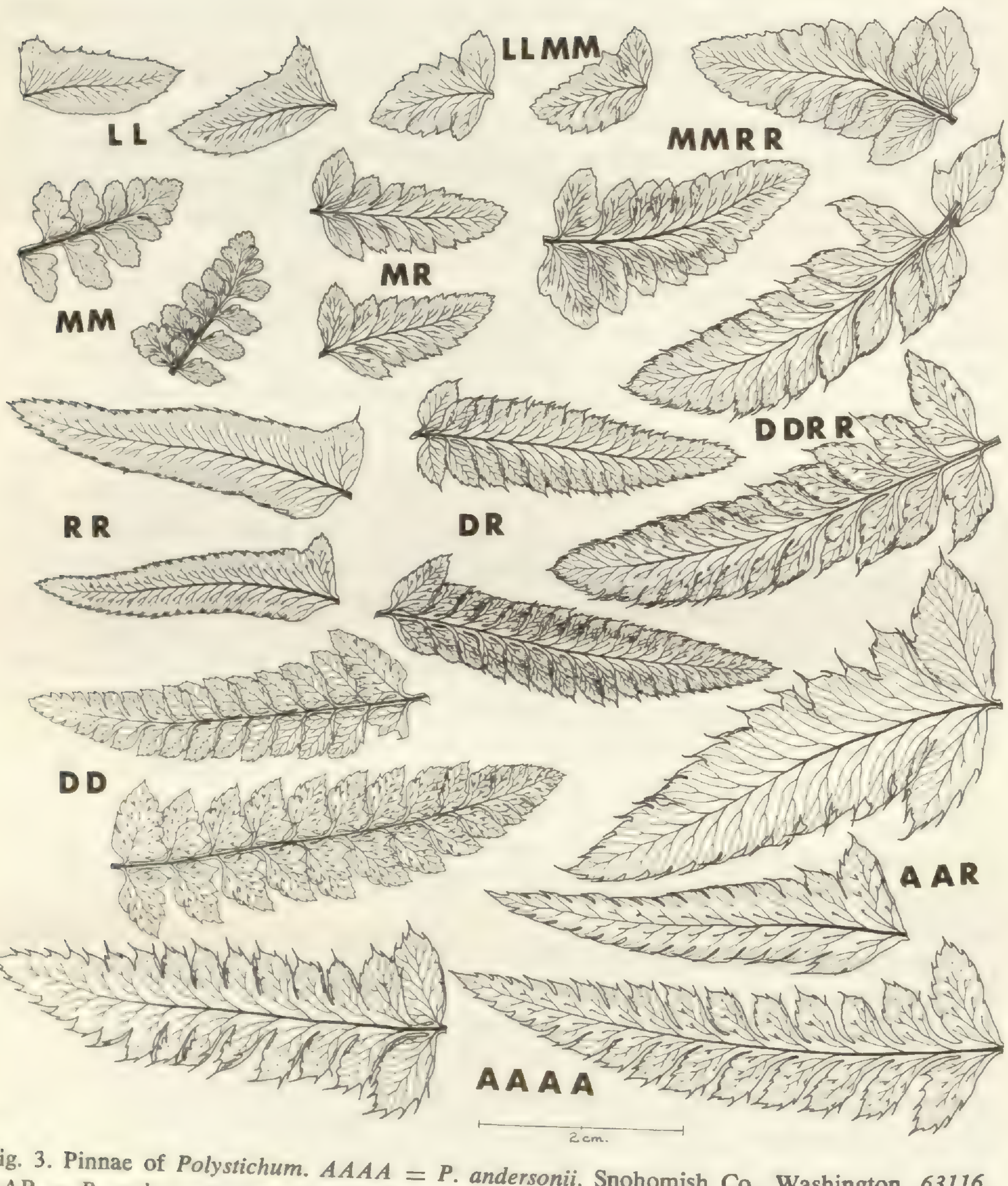

Fig. 3. Pinnae of *Polystichum*. *AAAA* = *P. andersonii,* Snohomish Co., Washington, *63116*. AAR = *P. andersonii* × *munitum,* same locality, *63115*. DD = *P. dudleyi,* Mendocino Co., California, *Branscomb*. DR = *P. californicum* (2*x*), Napa Co., California, *Branscomb*. DDRR = *P. californicum* (4*x*), Mendocino Co., California, *Branscomb*. LL = *P. lonchitis,* Bruce Peninsula, Ontario, *Hagenah* in 1960. LLMM = *P. kruckebergii,* Clallum Co., Washington, *Kruckeberg 5666*. MM = *P. mohrioides,* Kittitas Co., Washington, *63101*. MR = *P. scopulinum* (2*x*), same locality, *63093*. MMRR = *P. scopulinum* (4*x*), Kruckeberg garden, Chelan Co., Washington, *63125*. RR = *P. munitum,* Kittitas Co., Washington, *63090*. Collections at MICH, by Wagner unless otherwise noted.

P. mohrioides tend to have unusually smooth perine layers, in contrast to the much corrugated perines of the others. The spores are also larger than those of the other diploid basic species.

The spores of *P. mohrioides* are so large that the lengthwise diameter of the exospore (as seen in diaphane preparations) overlaps that of the tetraploids. This species is thus another exception to the commonly cited "rule" that diploids have smaller spores than tetraploids in groups of closely related taxa. Measurements of 10–spore samples from two collections each of the taxa involved follow a sequence of increasing spore size among the diploid sexual taxa: *P. lonchitis,* greatest exospore diameter averages 28–31μ; *P. munitum,* 29–32μ (probably not significantly different statistically from *P. lonchitis*); *P. dudleyi,* 33–35μ; and *P. mohrioides,* 37–40μ. For the reasons given, *P. mohrioides* has the most readily recognized spores in the group of diploid sexual taxa. Among the fertile derivative taxa (to be discussed below), the spore size sequence of small to large is as follows: *P. californicum,* 34–42μ; *P. kruckebergii,* 41–45μ; and *P. scopulinum,* 41–48μ. The influence of *P. mohrioides* on its presumed tetraploid hybrid derivatives is evidenced by their large spores.

Polystichum andersonii.—Anderson's Holly Fern, *P. andersonii,* was described twice under two specific names for what were probably minor variations by Hopkins (1913, 1917; also see Maxon, 1918), but it is a valid, now generally accepted species. One of the showiest of all Holly Ferns, its gracefully spreading fronds average about 6 dm long, but may reach nearly double this length in luxuriant habitats. Scattered from 45°N to nearly 60°N latitude (Taylor, 1970, p. 173), it flourishes in local colonies in cool, moist woods or rocky, mossy slopes. Although relationships have been suggested with other species, especially *P. braunii* (Spenner) Fée, *P. andersonii* differs from all of them in its distinctive combination of characteristics, including the presence of usually one scaly bud along the rachis in the distal portion of the frond. The abaxial epidermis shows unusually sinuous cell walls (*Fig. 7,* 3, 4). The form of the ultimate segments (*Fig. 3*) is strongly different from that of *P. dudleyi,* the basic species most likely to be confused with it. Of the basic species, *P. andersonii* is the only one which is tetraploid.

FERTILE DERIVATIVE TAXA

The California Holly Fern, *P. californicum,* the Crag Holly Fern, *P. scopulinum,* and Kruckeberg's Holly Fern, *P. kruckebergii,* all evidently result from reticulation of basic species. The evidence derives from several sources, especially the intermediacy that is apparent in a number of characters (*Figs. 1–5*), and for two of them actual field experience with primary hybrids which are obviously sterile and diploid, but which resemble the fertile tetraploid forms so closely as to be practically indistinguishable without microscopic study.

A typical example of **P. californicum** is shown in *Fig. 1* (DDRR). This is a large fern, usually over 5 dm tall. Morphologically it is intermediate between *P. dudleyi* and *P. munitum.* The leaflets are cut to the rachis only at the pinna base, the upper ⅔ or ¾ of the pinnae being merely lobed. When *P. californicum*

Fig. 4. Epidermal cells of *Polystichum*. Upper figure, adaxial; lower figure, abaxial. LL = *P. lonchitis*, Skamania Co., Washington, *63108*. LLMM = *P. kruckebergii*, Clallam Co., Washington, *Kruckeberg 5666*. MM = *P. mohrioides*, Kittitas Co., Washington, *63101*. MR = *P. scopulinum* (2*x*), same locality, *63093*. MMRR = *P. scopulinum* (4*x*), same locality, *63099*. RR = *P. munitum*, Skamania Co., Washington, *63109*. DR = *P. californicum* (2*x*). Napa Co., California, *Branscomb*. DDRR = *P. californicum* (4*x*), Humboldt Co., California, *Branscomb*. DD = *P. dudleyi*, Mendocino Co., California, *Branscomb*. Collections at MICH, by Wagner unless otherwise noted.

grows with *P. dudleyi* (with which it will readily hybridize), it can be distinguished quickly by its more leathery texture and much less divided pinnae (*Fig. 3,* DDRR and DD). Although highly localized and generally rare, *P. californicum* is nevertheless considerably more widespread and frequent than *P. dudleyi* (*Fig. 2*).[3] It most often occurs by itself or in the company of *P. munitum*.

Polystichum scopulinum is the intermediate between *P. mohrioides* and *P. munitum,* but it has a very much wider over-all range (*Fig. 2,* Taylor, 1970) than either of its presumed parents in North America. It is, however, confined to rocky crags in high mountainous places, preferring ultramafic rocks (Kruckeberg, 1964). The most striking feature of its range is the spectacular eastward disjunction of a population to the Gaspé Peninsula, Quebec, a distance of 2400 miles. Such a geographical separation, not only from its own metropolis but from the ranges of its parental species as well, probably is accounted for by long-distance west-to-east dispersal of a spore to an appropriate site on serpentine rock on Mount Albert (Wagner, 1972), rather than wholesale extinction of a formerly widespread and continuous mid-continental population. *Polystichum scopulinum* differs from *P. mohrioides* in the same directions that *P. californicum* differs from *P. dudleyi,* i.e., by character-trends that we associate with *P. munitum.* These include less frond cutting and thicker texture—both features readily noted in the field—as well as by such technical characters as less glandular epidermises (*Fig. 4,* LLMM vs. MM) and more rugose spores (*Fig. 5*). The veins of *P. scopulinum* are not so close as those of *P. mohrioides* (*Fig. 3*), and the segments are considerably more pointed, showing distinct (although small) projections, characters also believed to be due to the genetic influence of *P. munitum.*

I have elsewhere (Wagner, 1966) discussed **P. kruckebergii** in some detail, and so there is no need to consider here any but the most important points regarding it. These mainly have to do with the potential confusion of this taxon with *P. scopulinum,* which is a very similar fern. Both are usually small with fronds 2–3 dm long. Typically, *P. scopulinum* is somewhat larger and has more oblong and longer pinnae. *Polystichum scopulinum* has an average of about 12, rather than six teeth. The margins are not so bristly as in *P. kruckebergii,* and the pinna tips are not so pointed. *Polystichum scopulinum* also shows a longer petiole and correspondingly fewer reduced basal pinnae. I have discussed the evidence previously for regarding this fern as having originated as the hybrid of *P. mohrioides* and *P. munitum* (Wagner, 1966). So far as present records go, *P. kruckebergii* is considerably rarer and less widespread than *P. scopulinum* (*Fig. 2;* Taylor, 1970).

Cronquist (*in* Hitchcock et al., 1969, p. 69) suggests that there may be intergradation between *P. kruckebergii* and *P. scopulinum.* According to him,

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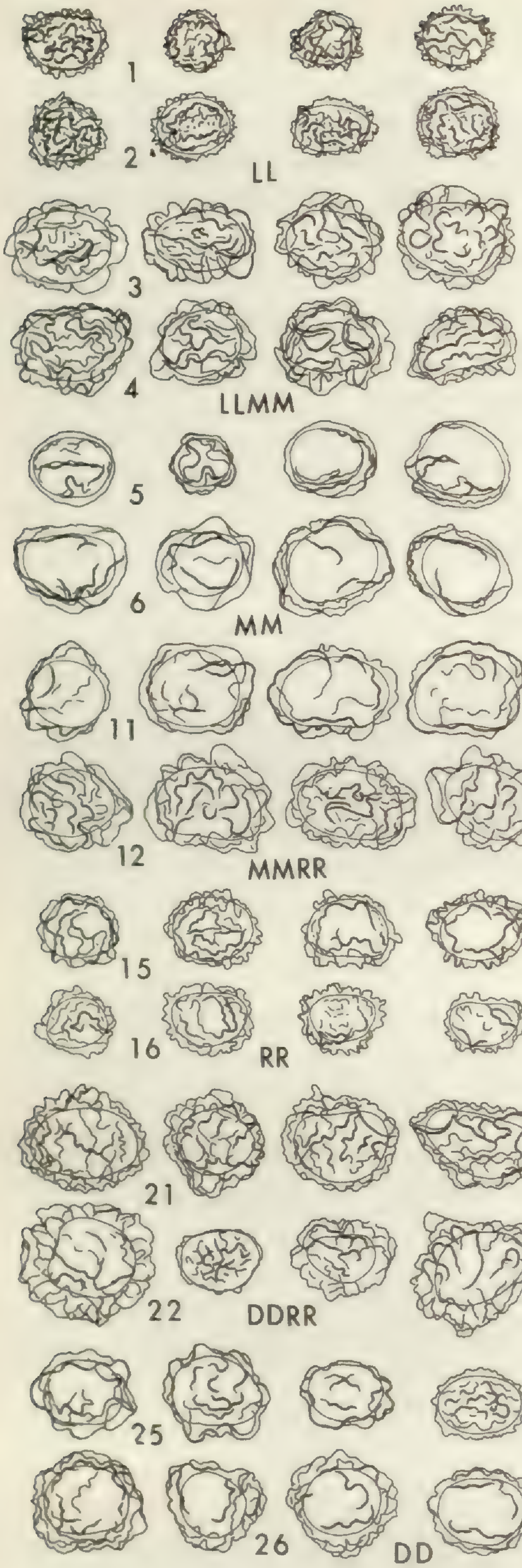
[3] Not shown on *Fig. 2* are collections from Eatonville, Pierce County, Washington, collected by J. B. Flett (WTU and US) that have been identified as *P. californicum* but which, I believe, may also represent *californicum*-like large forms of *P. scopulinum.* Attempts should be made to rediscover these interesting populations.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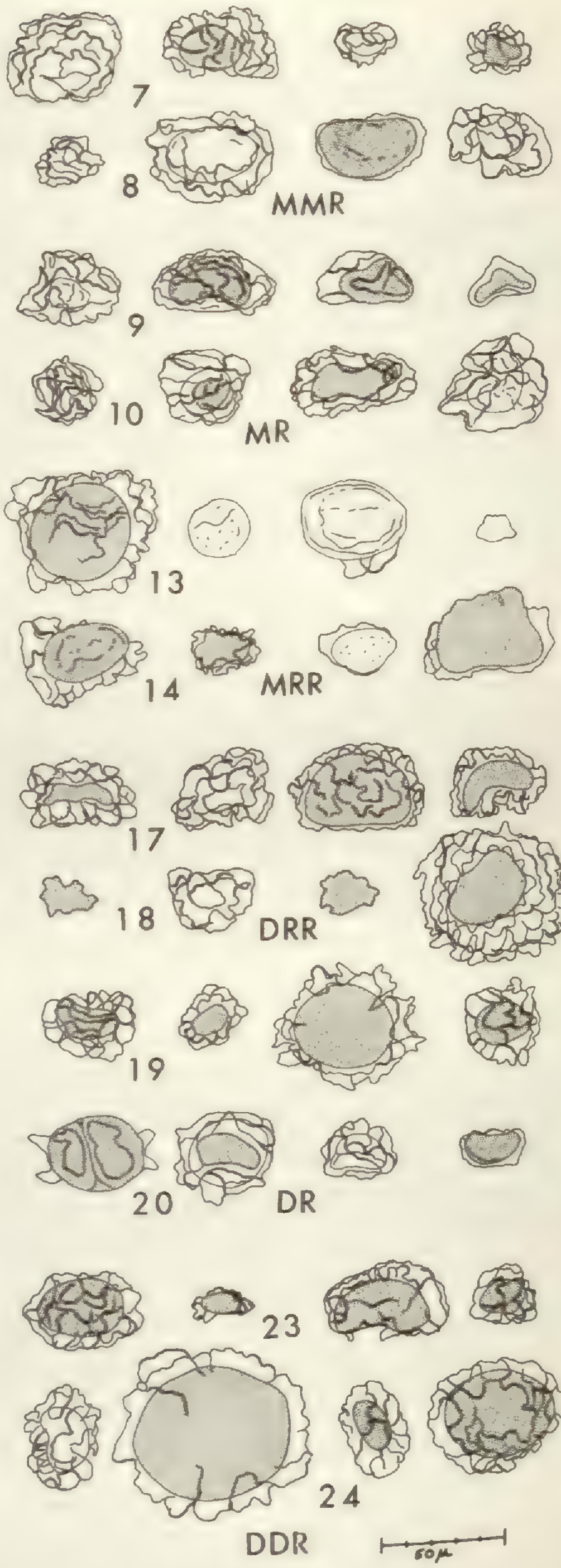
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"The difficulty of distinguishing some specimens of *P. scopulinum* from *P. kruckebergii* raises the suspicion that the two may be interfertile. . ." In view of the seeming intermediates that are occasionally encountered (at least in some localities where the two are sympatric) between *P. munitum* and *P. lonchitis,* the presumed ancestors of these tetraploids, it would not be surprising if hybridization of the derivative taxa took place. The matter should be explored, starting with habitats where seeming introgessant individuals of LL and RR are found.

STERILE DERIVATIVE TAXA

Although the sterile derivative taxa are much rarer than the fertile ones, they are of special interest for what they can instruct us about the nature of their parents, both ancestral and derived. Their spores are abortive, as demonstrated by their variable size and irregular morphology (*Fig. 5,* right-hand column; *Fig. 7,* 7, 8), as well as by direct germination tests. There are three major groups of sterile hybrids. All of the hybrids known as yet involve *P. munitum* directly or indirectly. No sterile hybrids involving *P. kruckebergii* have been encountered.

Polystichum californicum group.—The best localities for studying these plants are ones where all three sexual taxa—*P. dudleyi* (2*x*), *P. munitum* (2*x*), and *P. californicum* (4*x*)—grow together, as in the damp, rich canyons of the Napa Valley of California. A random sampling of plants may reveal a surprisingly high percentage which are sterile. For example, in September, 1961 I made a germination test using spores from 18 plants collected about three miles north of St. Helena. The plants involved resembled more or less the traditional concept of *P. californicum* or they verged toward *P. dudleyi* or toward *P. munitum.* Only five of those I collected turned out to be fertile! Later, the reasons became apparent. Some had the cytogenetic constitution DR (i.e., they were primary hybrids of *P. dudleyi* and *P. munitum*), some were DDR (judging from the chromosomes, *Fig. 6,* and the morphology of the fronds, *Figs. 1, 3*), and some DRR (on the same grounds). Such occurrences are very well known in the

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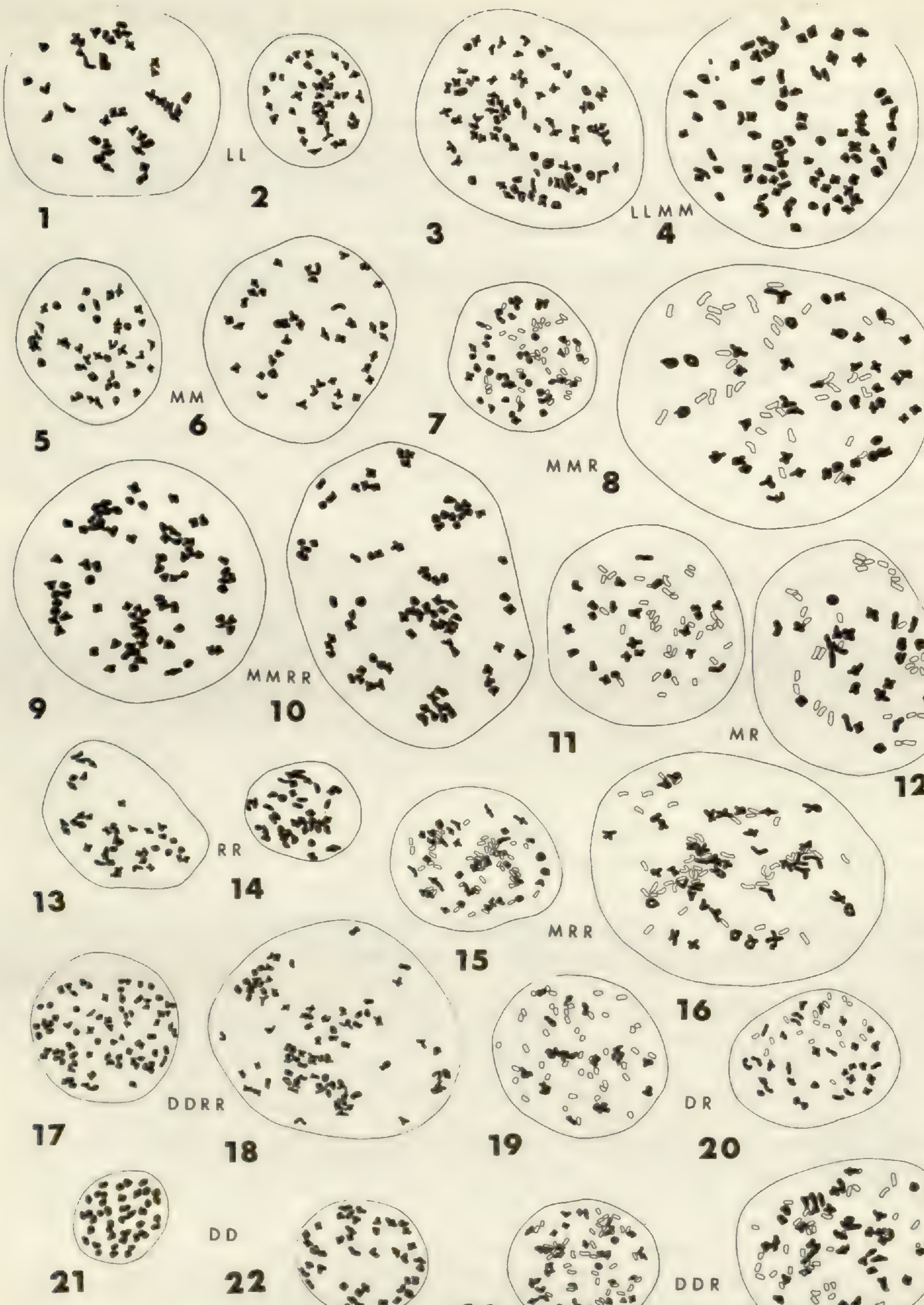
Fig. 5. Spores of *Polystichum.* LL = *P. lonchitis.* 1. Olympic Mountains, Washington, *WTU 30206.* 2. Unalaska, Alaska, *WTU 101409.* LLMM = *P. kruckebergii.* 3. Clallam Co., Washington, *Thompson 10364* (WTU). 4. Same locality, *US 1814392.* MM = *P. mohrioides.* 5. Kittitas Co., Washington, *Thompson 5870* (WTU). 6. Same locality, *WTU 111199.* MMR = *P. mohrioides* × *scopulinum.* 7, 8. Kittitas Co., Washington, *Wagner 63098* (MICH). MR = *P. scopulinum* (2*x*). 9, 10. Kittitas Co., Washington, *Wagner 63093* (MICH). MMRR = *P. scopulinum* (4*x*). 11. Plumas Co., California, *US 624053.* 12. San Bernardino Co., California, *US 70854.* MRR = *P. munitum* × *scopulinum.* 13, 14. Kittitas Co., Washington, *Wagner 63089* (MICH). RR = *P. munitum.* 15. Mendocino Co., California, *UC 582865.* 16. Jefferson Co., Washington, *UC 740039.* DRR = *P. californicum* × *munitum.* 17. Napa Co., California, *UMBG 22188-3* (MICH). 18. Sonoma Co., California, *Branscomb type 5* (MICH). DR = *P. californicum* (2*x*). 19. Mendocino Co., California, *Branscomb b* (MICH). 20. Same locality, *Branscomb* (MICH). DDRR = *P. californicum* (4*x*). 21. Pierce Co., Washington, *WTU 174854.* 22. Mendocino Co., California, *Branscomb* (MICH). DDR = *P. californicum* × *dudleyi.* 23, 24. Santa Rosa, California, *UMBG 22188-2* (MICH). DD = *P. dudleyi.* 25. Santa Clara Co., California, *US 468285.* 26. Monterey Co., California, *UC 797450.*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biosystematic literature of the ferns. What is remarkable is that both *de novo* diploid hybrids co-exist with derivative allotetraploids side-by-side in the same habitats, a state of affairs that to my remembrance has not previously been reported. And, apparently, such hybridization goes on year in and year out. When Florence S. Wagner and I revisited the locality north of St. Helena 12 years after the first visit, we found no change; specimens of backcrosses and diploid sterile hybrids were just as common as they were earlier. *Polystichum dudleyi* was common, *P. californicum* likewise (apparently in both the 2*x* and 4*x* forms), and *P. californicum* × *dudleyi* and *P. munitum* were both frequent. (However, on the latter occasion, in March 1973, we did not notice any specimens of *P. californicum* × *munitum,* but nightfall was approaching and our time was limited.)

Polystichum scopulinum group.—To our great satisfaction, almost exactly the same conditions that are described above involving populations of *P. californicum* and its diploid ancestors were found to exist also in conjunction with this group. An expedition by A. R. Kruckeberg and myself to an area along Beverley Creek in Kittitas County in the Wenatchee Mountains of Washington in June 1963 (the same spot later revisited by the Fern Foray of the 11th International Botanical Congress in August, 1969) revealed the following sterile hybrids: *P. mohrioides* × *munitum, P. mohrioides* × *scopulinum,* and *P. munitum* × *scopulinum*—the first diploid, the second and third triploid. Once again one of the basic species, *P. munitum,* was less common than the other with which it had generated the hybrids.

Polystichum andersonii group.—Our most remarkable results in this investigation involve Anderson's Holly Fern. Although only one of the neighboring species has been found as yet to hybridize with it, the implications of what we observed seem, at the present time, most mysterious. The locality which I studied under the guidance of A. R. Kruckeberg is in Snohomish County, Washington. It is a beautiful and primitive, shaded, mossy talus slope above Perry Creek, at an altitude of approximately 3000 ft. Only three polystichums occur

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Fig. 6. Chromosome tracings of *Polystichum*. LL = *P. lonchitis*. 1. Skamania Co., Washington, *63108* (*n*=41 II). 2. Bruce Peninsula, Ontario, *Hagenah garden* in 1960 (*n*=41 II). LLMM = *P. kruckebergii*. 3, 4. Clallam Co., Washington, *Kruckeberg 5666* (*n*=82 II). MM = *P. mohrioides*. 5, 6. Kittitas Co., Washington, *63095* (*n*=41 II). MMR = *P. mohrioides* × *scopulinum*. 7. Kittitas Co., Washington, *63094-2* (42 II + 38 I). 8. Same locality, *63098* (43 II + 36 I). MMRR = *P. scopulinum* (4*x*). 9. Kittitas Co., Washington, *63099* (*n*=82 II). 10. Same locality, *63091* (*n*=82 II). MR = *P. scopulinum* (2*x*). 11. Kittitas Co., Washington, *63093* (23 II + 36 I). 12. Same collection (24 II + 34 I). RR = *P. munitum*. 13. Kittitas Co., Washington, *63090* (*n*=41 II). 14. "Sawyer's Barren, Solomon R.," *Quick* (*n*=41 II). MRR = *P. munitum* × *scopulinum*. 15. Kittitas Co., Washington, *63089* (38 II + 48 I). 16. Same collection (39 II + 45 I). DDRR = *P. californicum* (4*x*). 17. 4 miles E of Ukiah, Mendocino Co., California, *Branscomb* (*n*=82 II). 18. 2 miles N of Pierce, Mendocino Co., California, *Branscomb* (*n*=82 II). DR = *P. californicum* (2*x*). 19. Mendocino Co., California, *Branscomb* (19 II + 44 I). 20. Same collection (32 II + 18 I). DD = *P. dudleyi*. 21, 22. Mendocino Co., California, *Branscomb* (*n*=41 II). DDR = *P. dudleyi* × *munitum*. 23. Napa Co., California, *UMBG 22188-2* (41 II + 41 I). 24. Same locality, *UMBG 22188-B* (39 II + 45 I). Collections at MICH, by Wagner unless otherwise noted.

here—*P. munitum, P. andersonii,* and *P. lonchitis.* Of these, only the hybrid between the first two was found (although *P. andersonii* × *lonchitis* is a likely combination at this locality and should be sought here or elsewhere where conditions are suitable). *P. andersonii* is a tetraploid (*Fig. 8,* AAAA). Its colonies are local on wooded, steep, mossy talus in association with the abundant *P.*

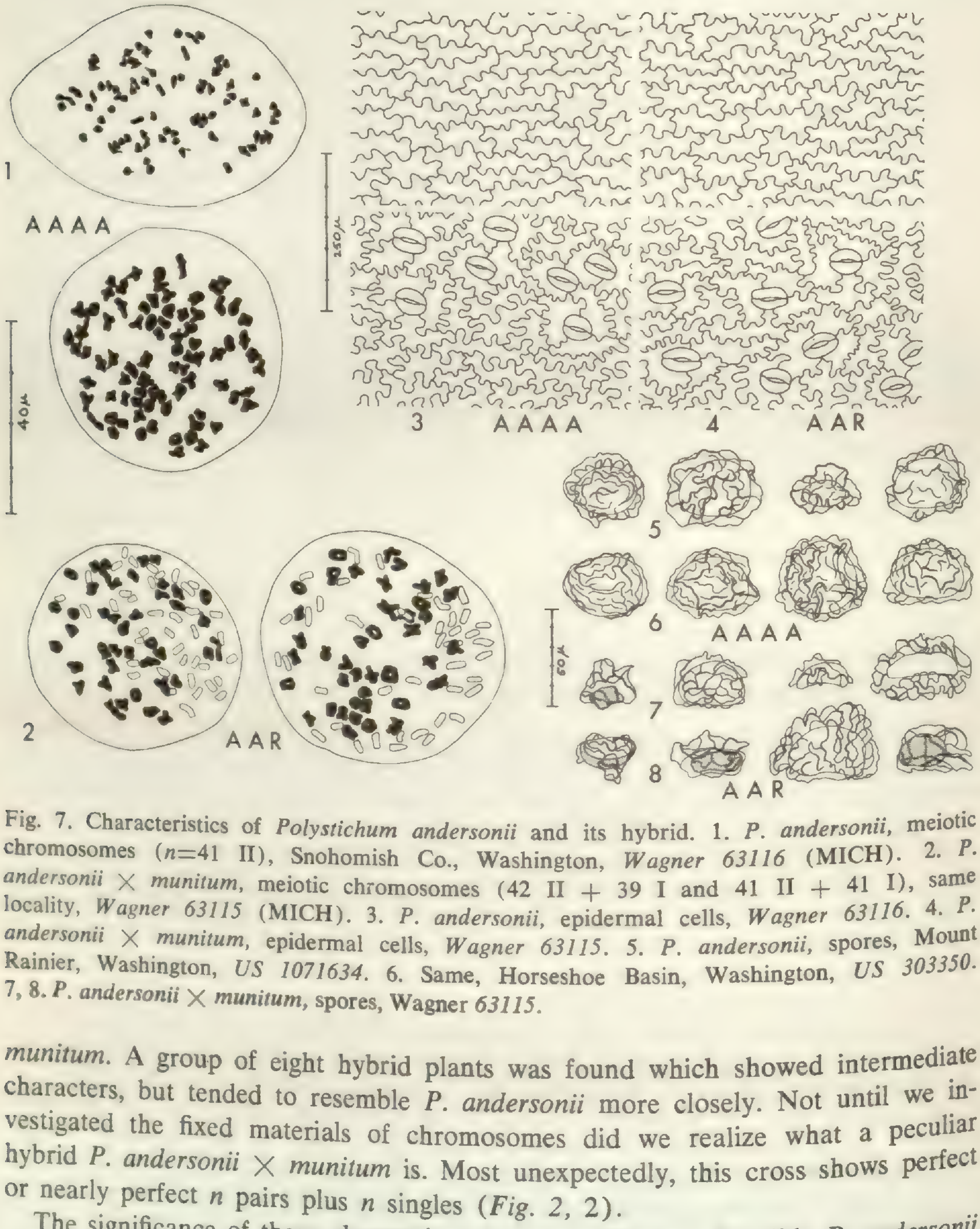


Fig. 7. Characteristics of *Polystichum andersonii* and its hybrid. 1. *P. andersonii,* meiotic chromosomes (*n*=41 II), Snohomish Co., Washington, *Wagner 63116* (MICH). 2. *P. andersonii* × *munitum,* meiotic chromosomes (42 II + 39 I and 41 II + 41 I), same locality, *Wagner 63115* (MICH). 3. *P. andersonii,* epidermal cells, *Wagner 63116.* 4. *P. andersonii* × *munitum,* epidermal cells, *Wagner 63115.* 5. *P. andersonii,* spores, Mount Rainier, Washington, *US 1071634.* 6. Same, Horseshoe Basin, Washington, *US 303350.* 7, 8. *P. andersonii* × *munitum,* spores, Wagner *63115.*

munitum. A group of eight hybrid plants was found which showed intermediate characters, but tended to resemble *P. andersonii* more closely. Not until we investigated the fixed materials of chromosomes did we realize what a peculiar hybrid *P. andersonii* × *munitum* is. Most unexpectedly, this cross shows perfect or nearly perfect *n* pairs plus *n* singles (*Fig. 2,* 2).

The significance of these observations is not at all clear. Possibly *P. andersonii* is an allopolyploid and one of its genomes is that of *P. munitum.* Or P.

andersonii may be autopolyploid, the genomes of which are essentially homologous, but which, when placed together with a foreign genome, show autosyndesis (i.e., they will pair with themselves). The cytogenetic formula that embodies the former hypothesis would be $A^1A^1R^2R^2$ and the latter $A^1A^1A^2A^2$.

The problem with an allopolyploid hypothesis to explain this situation is that the characters of *P. andersonii* seem so distinct from those of *P. munitum* that ancestral affinity seems unlikely. *Polystichum andersonii* seems to be a divergent, basic species. Perhaps by some genetic accident different pairing factors (indicated in the formulae by superscript numbers) arose. Such an

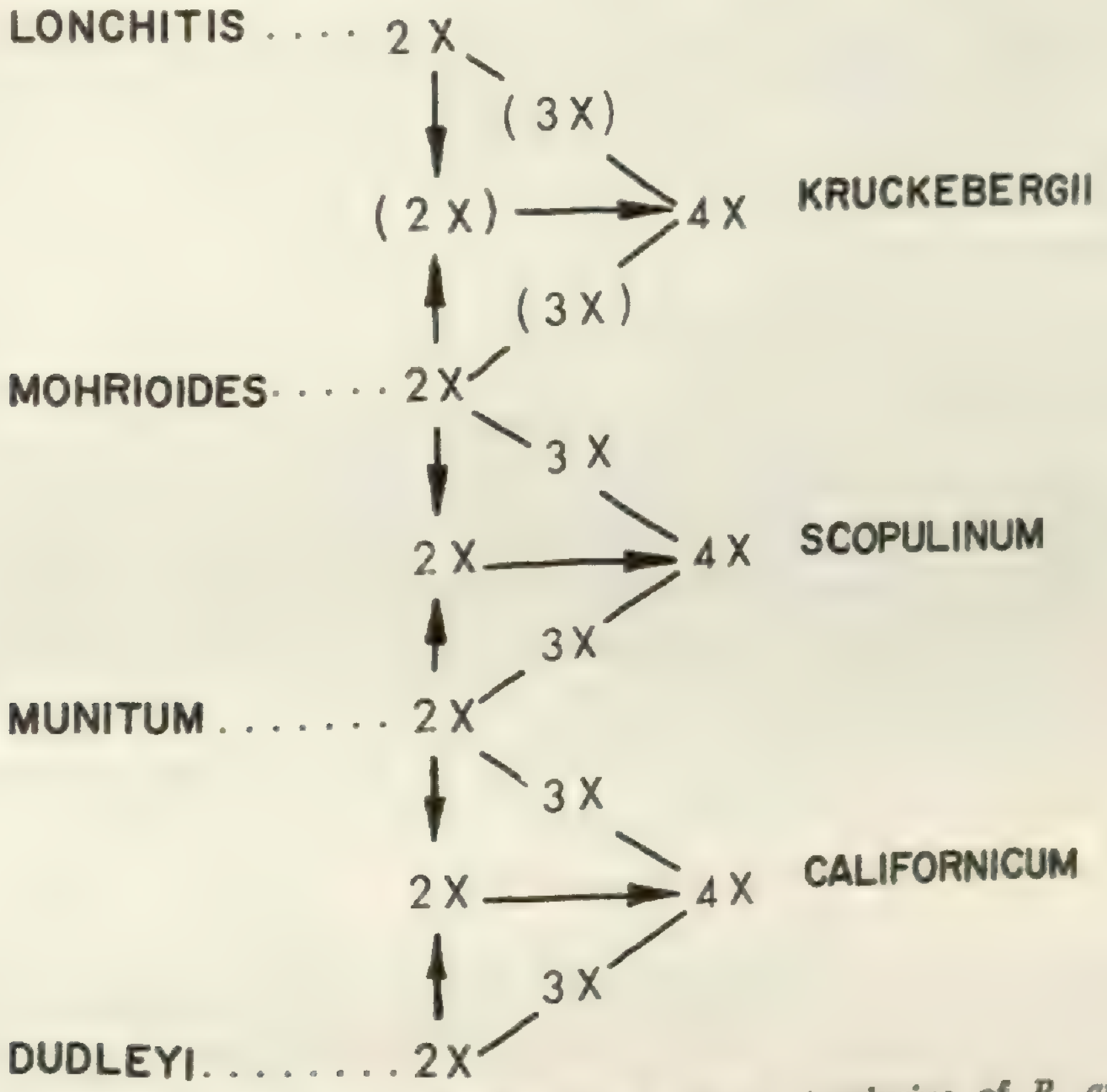


Fig. 8. Reticulate relationships of the western Holly Ferns (exclusive of *P. andersonii*).

autopolyploid, because of its differentiated synaptic controls, would be expected to behave normally at meiosis and form 82 pairs. In a hybrid with another species, however, the genomes A^1A^2 would then pair with one another rather than with the alien genome. The pairing would be $A^1A^2 + R$ and would not constitute evidence for the ancestral genetic relationship of *P. andersonii* to *P. munitum*. The problem obviously needs further study. One experimental approach would involve production of polyhaploids of *P. andersonii* by induced apogamy in order to determine whether, in fact, self-pairing can occur.[4]

[4] More and more evidence is accumulating that autosyndetic pairing can occur among ferns. Vida (1970, 1972) presents some of the most convincing examples, involving members of the Asplenioideae. He and his co-workers have found, for example, that in hybrids of 2*x* *Phyllitis* and 4*x* *Asplenium*, where the respective chromosomes can be distinguished because of size differences, the chromosomes from the tetraploid *Asplenium* will pair with one another.

DISCUSSION

The western North American Holly Ferns display network relationships, as evidenced by their geography, ecology, morphology, and cytology. A scheme (excluding *P. andersonii* and its hybrid) presented in *Fig. 8* illustrates my concepts of reticulate affinity of seven named taxa plus six additional, unnamed sterile taxa.

Regarding the inter-relationships of these plants, however, numerous problems remain. I have already remarked on the problem of *P. andersonii* and the cytological behavior of its hybrid with *P. munitum,* a question of allopolyploidy versus autopolyploidy.

Further problems with patterns of pairing involve the different ploidal levels of the other taxa. The diploid sterile hybrids in our western Holly Ferns show an unexpectedly high degree of pairing. Although we were somewhat limited by materials available for study, we found that in a total of 14 sporocytes from 5 plants of diploid *P. dudleyi* × *munitum* hybrids, the average was 26 pairs, range 19–33. In a total of 5 sporocytes from 1 plant of diploid *P. mohrioides* × *munitum,* the average was 24 pairs, range 20–30. Why do these ferns differ so much from the majority of crosses previously reported, in which pairing is minimal and the bivalents few or none? How is it possible that when the chromosome numbers of these plants are doubled, the pairing becomes essentially perfect? We should expect multivalents. Correspondingly, the triploid backcrosses achieve perfect or nearly perfect 41 pairs plus 42 singles, a situation also congruent with the "sloppy" pairing seen in the sterile diploids.

Of special nomenclatural interest are those hybrids which are evidently genetically identical or nearly identical to fertile allotetraploids but which are sterile and diploid. We have found *P. dudleyi* × *munitum* and *P. mohrioides* × *munitum.* A third, *P. lonchitis* × *mohrioides,* will probably be found through future collecting. How should we treat them nomenclaturally? Because their only differences are those connected with ploidal level and its effect on fertility, I propose that we treat the sterile diploids as members of the same taxon as the fertile tetraploids. Also, since the evidence seems convincing for the hybrid nature of these tetraploids, then this important fact should be expressed by the use of the multiplication sign. Accordingly, the nomenclature would be, for example: *Polystichum* × *californicum* (fertile 4*x*) and *P.* × *californicum* (sterile 2*x*). In this way, the designations would be brief and yet contain the maximum information.

LITERATURE CITED

ABRAMS, LeROY. 1940. Illustrated flora of the pacific states. Washington, Oregon, and California. Vol. I. Ophioglossaceae to Aristolochiaceae. Stanford Univ. Press, Stanford, Calif. Pp. i–ix, 1–538.

ALSTON, A. H. G. 1940. The correct application of the name Polystichum aculeatum. J. Bot. Brit. & For. **78:** 161–164.

CRONQUIST, A., A. H. HOLMGREN, N. H. HOLMGREN, and J. L. REVEAL. 1972. Intermountain Flora. Vascular Plants of the Intermountain West, U.S.A. Vol. 1. Hafner, New York. Pp. i–iv, 1–270.

EWAN, J. 1942. Annotations on West American Ferns—II. Amer. Fern J. **32:** 90–104.
————. 1944. Annotations of Western American Ferns—III. Amer. Fern J. **34:** 107–120.
HITCHCOCK, C. L., A. CRONQUIST, and M. OWNBEY. 1969. Vascular Plants of the Northwest. Part I: Vascular Cryptogams, Gymnosperms, and Monocotyledons. Univ. Washington Press, Seattle. Pp. 1–914.
HOPKINS, L. S. 1913. A new Polystichum from British Columbia. Amer. Fern J. **3:** 116–118.
————. 1917. XI. A new species of fern (Polystichum jenningsi). Ann. Carnegie Mus. **11:** 362–363, *pl. xxxvii.*
JEPSON, W. L. 1923. A manual of the flowering plants of California. Sather Gate Bookshop, Berkeley, Calif. Pp. 1–1238.
KRUCKEBERG, A. R. 1964. Ferns associated with ultramafic rocks in the Pacific Northwest. Amer. Fern J. **54:** 113–126.
LÖVE, Å. and O. T. SOLBRIG. 1964. IOPB chromosome number reports. I. Taxon **13:** 99–110.
MANTON, IRENE and T. REICHSTEIN. 1961. Zur Cytologie von Polystichum braunii (Spenner) Fée und seiner Hybriden. Ber. Schweiz. Bot. Ges. **71:** 370–383.
MAXON, W. R. 1918. Polystichum andersonii and related species. Amer. Fern J. **8:** 33–37.
MEYER, D. E 1959. Polystichum × eberlei (P. braunii × lonchitis), ein neuer Farnbastard. Nova Hedwigia **1:** 105–114, *pl. 20, 21.*
MORZENTI, VIRGINIA M. 1962. A first report on pseudomeiotic sporogenesis, a type of spore reproduction by which "sterile" ferns produce gametophytes. Amer. Fern J. **52:** 69–78.
MUNZ, P. A., and D. D. KECK. 1959. A California Flora. Univ. Calif. Press, Berkeley and Los Angeles. Pp. 1–1681.
RAVEN, P. H. 1963. Amphitropical relationships in the floras of North and South America. Quart. Rev. Biol. **38:** 151–177.
————, and HELENA CURTIS. 1970. Biology of Plants. Worth Publishers, New York. Pp. i–xi, 1–706.
SLEEP, ANNE. 1966. Some cytotaxonomic problems in the fern genera Asplenium and Polystichum. Doctoral Dissertation. University of Leeds.
————, and T. REICHSTEIN. 1967. Der Farnbastard Polystichum × meyeri hybr. nov. = Polystichum braunii (Spenner) Fée × P. lonchitis (L.) Roth and seine Cytologie. Bauhinia **3:** 299–314.
TAYLOR, T. M. C. 1970. Pacific Northwest ferns and their allies. Univ. Toronto Press, Toronto. Pp. i–x, 1–241.
THOMPSON, R. H. and R. L. COFFIN. 1940. A natural hybrid between Polystichum braunii (Spenner) Fée and P. acrostichoides (Michx.) Schott. Amer. Fern J. **30:** 81–88.
VIDA, G. 1970. The nature of polyploidy in Asplenium ruta-muraria L. and A. lepidum C. Presl. Caryologia **23:** 525–547.
————. 1972. Cytotaxonomy and genome analysis of the European ferns. Symp. Biol. Hung. **12:** 51–60.
WAGNER, W. H., Jr. 1963. A biosystematic survey of United States ferns—Preliminary abstract. Amer. Fern J. **53:** 1–16.
————. 1966. Two new species of ferns from the United States. Amer. Fern J. **56:** 3–17.
————. 1972. Disjunctions in homosporous vascular plants. Ann. Missouri Bot. Gard. **59:** 203–217.
————, and D. J. HAGENAH. 1954. A natural hybrid of Polystichum lonchitis and P. acrostichoides from the Bruce Peninsula. Rhodora **56:** 1–6, *pl. 1198.*

The Mexican Species of Thelypteris Subgenera Amauropelta and Goniopteris

ALAN R. SMITH*

Recent collections of *Thelypteris* from Mexico, especially from the fern-rich states of Oaxaca and Chiapas, necessitate the description of several new taxa and reëvaluation of some older circumscriptions by the last monographer of the genus (Christensen, 1913). The large number of Neotropical species of *Thelypteris* (ca. 300) and the widespread distribution of many of these species make a systematic study of the two largest subgroups, subg. *Goniopteris* and subg. *Amauropelta,* unfeasible at this time. In lieu of such a revision, admittedly badly needed, I present below keys to the Mexican species of subgenera *Amauropelta* and *Goniopteris*. The keys are followed by descriptions of new taxa, new combinations, and other brief notes. For the remaining two subgroups of *Thelypteris* with more than single species in Mexico, i.e., *Cyclosorus* and *Meniscium,* there exist current treatments (Smith, 1971b; Maxon & Morton, 1938).

I am grateful to the curators at CAS, DS, GH, MICH, NY, and US for making their collections available for study.

Thelypteris subg. Goniopteris (Presl) Duek, Adansonia II, 11: 720. 1971.

Goniopteris Presl, Tent. Pterid. 181. 1836. LECTOTYPE: *Polypodium crenatum* Swartz [=*Thelypteris poiteana* (Bory) Proctor], chosen by J. Smith, Hist. Fil. 190. 1875.

Dryopteris subg. *Goniopteris* (Presl) C. Chr., Biol. Arb. til. Eug. Warm. 84. 1911.

Thelypteris sect. *Goniopteris* (Presl) Morton, Amer. Fern J. **53:** 154. 1963.

There is no unanimity of opinion with regard to the rank that *Goniopteris* should be accorded. It is clearly a natural group and close to no others in the New World with the exception of *Meniscium*. It could easily stand as a genus, but this would require many new combinations that I am not yet prepared to make. I include within its circumscription one species, *T. blanda,* that has heretofore been placed in subg. *Lastrea* (*sensu* C. Chr., 1913).

KEY TO MEXICAN THELYPTERIS SUBG. GONIOPTERIS

1. Veins meniscioid, with 3 or more pairs of veins from adjacent segments anastomosing with an excurrent vein that ends before reaching the next pair of anastomosing veins.
   2. Sporangial walls with several short setae; meniscioid veins 3–5-seriate; costae below moderately hairy, the hairs mostly 0.2–0.4 mm long.....*T. poiteana* (Bory) Proctor
2. Sporangial walls glabrous (rarely with a few minute setae in *T. meniscioides*); meniscioid veins 7–12-seriate.
   3. Costae, veins, and leaf tissue moderately to rather densely hairy below, the hairs up to 1.5 mm long, with many hairs ca 1.0 mm long...*T. ghiesbreghtii* (Hooker) Morton
   3. Costae, veins, and leaf tissue glabrous or nearly so below, the hairs if present less than 0.2 mm long.....*T. meniscioides* (Liebm.) Reed

* Herbarium, Department of Botany, University of California, Berkeley, CA 94720.

1. Veins free (meeting the leaf margin above the sinus), connivent at the sinus, or the lower 1–2(3) pair(s) united with an excurrent vein to the sinus.
   4. Fronds arching, radicant at or near the tip and producing new fronds; pinnae 2.5 cm long or less, entire to lobed about ¼ of their width.....*T. reptans* (Gmel.) Morton
   4. Fronds not rooting at the tip (*T. paucipinnata* and *T. resiliens* sometimes producing rachis buds proximal to the tip); pinnae greater than 2.5 cm long (except in *T. polyphylla* and rarely *T. blanda*), shallowly to deeply lobed more than ¾ of their width.
      5. Sori supramedial to submarginal; indusia persistent and relatively large; costae below without stellate hairs.
         6. Costae below glabrous; indusia glabrous or with marginal hairs 0.1 mm long or less; pinnae incised about ⅓ or less.....*T. paucipinnata* (Donn. Smith) Reed
         6. Costae below moderately hairy; indusia with marginal hairs up to 0.3 mm long; pinnae incised about ½ of the way to the costae.....*T. schaffneri* (Fée) Reed
      5. Sori medial, supramedial, or subcostular; indusia absent, or if present minute and often overlooked; costae below with or without stellate hairs.
         7. Lamina with a terminal pinna resembling the lateral ones; sporangial walls with or without minute setae or furcate hairs.
            8. Pinnae serrulate to lobed ⅓ to the costae, cuneate at the base; basal veins upcurved and anastomosing under acute angles, the following pairs usually also anastomosing.....*T. obliterata* (Swartz) Proctor
            8. Pinnae incised ½ to ¾ to the costae, truncate at the base; only the basal pair of veins anastomosing at an obtuse angle, or the veins connivent at the sinus.
               9. Rachis, costae, costules, and veins below glabrous.....*T. toganetra* A. Reid Smith
               9. Rachis, costae, costules, and often veins below pubescent.
                  10. Veins united at an obtuse angle with an excurrent vein toward the sinus; sporangia setose.....*T. tetragona* (Swartz) Small
                  10. Lowermost pair of veins from adjacent segments connivent at the sinus; sporangia glabrous.....*T. imbricata* (Liebm.) Reed
         7. Lamina without a distinct terminal pinna, upwards gradually narrowed into a pinnatifid apex; sporangia glabrous.
            11. Costae, veins, and sometimes leaf tissue below with rather dense, stellate or furcate hairs.
               12. Some hairs on costae and leaf tissue below anchor-shaped, i.e., with 2 short recurved branches at the tip.....*T. biolleyi* (Christ) Proctor
               12. Anchor-shaped hairs absent below.....*T. hatchii* A. Reid Smith
            11. Costae, veins, and lamina glabrous or with unbranched hairs below.
               13. Pinnae less than 7 cm long, often less than 5 cm long; indusia always absent.
                  14. Pinna segments with marginal setae about 0.3 mm long; pinnae less than 2.5 cm long, less than 1.0 cm wide; pinnae of most developed fronds strongly inequilateral, the basal acrosporic segments larger and less oblique than the basiscopic segments; fewer than 4 pairs of veins per segment. *T. polyphylla* (Copel.) Reed
                  14. Pinna segments without marginal setae; pinnae (2.5)4–7 cm long, up to 1.7 cm wide; pinnae not strongly inequilateral; up to 8 pairs of veins per segment.....*T. blanda* (Fée) Reed
               13. Pinnae greater than 8 cm long; indusia minute but usually easily visible.
                  15. Indusia densely short pubescent; rachis buds absent; fronds subdimorphic, the fertile contracted and taller than the sterile; leaf tissue not warted below. *T. munchii* A. Reid Smith
                  15. Indusia short-ciliate on the margin; rachis buds present or absent; fronds monomorphic, leaf tissue usually warted below. *T. resiliens* (Maxon) A. Reid Smith

7494 **Thelypteris toganetra A. Reid Smith, sp. nov.**

Rhizoma suberectum vel repens, ad apicem paleis brunneis minutis stellato-pilosis dense vestitum; frondes usque ad 70 cm longae, 30 cm latae, pinnis lateralibus 10–16-jugis et pinna apicali distincta, habitu texturaque frondibus *T. tetragonae* (Swartz) Small atque specierum affinium similes; rhachis utrinque glabra, vel supra paucis pilis stellatis minus quam 0.1 mm longis; pinnae latitudine ca 0.5–0.66-incisae, lobis subfalcatis apice acutis, pinnae infimae segmentis basalibus aliquantum deminutis; costae utrinque glabrae vel supra paucis pilis simplicibus ca 0.2 mm longis; costulae, venae, et pagina inter venas utrinque glabrae praeter frequentes glandulas rubras sessiles dispersas infra; venae 8–15-jugae, 1 vel 2 paribus infimis cujusque segmenti contigui conniventibus ad sinum; sori mediales exindusiati; sporangia glabra.

TYPE: Atoyac river, Veracruz, Mexico, 600 m, 3 Mar 1938, *Copeland Herb. 34* (UC; isotypes GH, MICH, US).

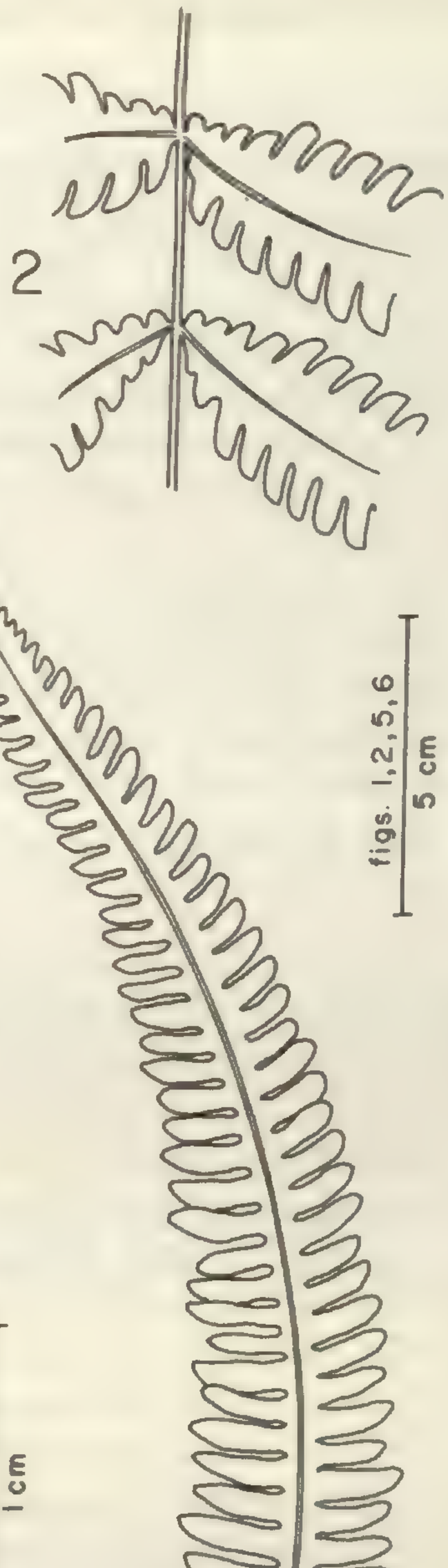
ADDITIONAL SPECIMENS EXAMINED:

BRITISH HONDURAS: Toledo, near Central Camp, Edwards Road beyond Columbia, 9 Jun 1951, *Gentle 7359* (UC, US); Belize River, Mount Hope, *Lundell 1998* (MICH). **GUATEMALA: Alta Verapaz:** Sebol, near Río Sebol, *Contreras 4558* (US). **MEXICO: Chiapas:** Lagos de Monte Bello, Nov 1971, *Breedlove & Smith s.n.* (UC). **Oaxaca:** Dto. Tuxtepec, 2 km N of Chiltepec, ca 200 ft, 30 Jul 1971, *Mickel 5800* (NY), *5801* (NY). **San Luis Potosi:** Vicinity of Rascon, 19–22 Jun 1905, *Palmer 660* (GH, US); N of Valles, 200 m, 27 Dec 1937, *Copeland Herb. s.n.* (MICH, UC); Along road to Jalpan, ca 12 mi NE of Xilitla, 29 Mar 1961, *King 4380* (UC, US).

This species is most closely related to *Thelypteris* (*Goniopteris*) *tetragona* (Swartz) Small and *T. imbricata* (Liebm.) Reed, from which it differs in the completely glabrous costae and rachis below. On most specimens of *T. toganetra* cited I find scattered, small, reddish, sessile glands along the costules and veins below, a character I have not seen in any other species of *Goniopteris*. Most specimens cited are sterile; notes with the type (fertile) indicate that the population was mostly sterile, and I have observed large sterile colonies in Chiapas covering 100 ft^2 or more. The species apparently reproduces extensively by vegetative means, i.e., the creeping rhizomes. A chromosome count from *Breedlove & Smith s.n.* showed $n = 36$. The epithet is an anagram of *tetragona*.

7492 **Thelypteris hatchii A. Reid Smith, sp. nov.** Figs. 1–3

Rhizoma erectum vel suberectum, basibus stipitum veterum et radicibus usque ad 1.5 mm crassis absconditum, ad apicem paleis brunneis sparsim stellato-pilosis vestitum; stipites pauci, 20–45 cm longi, brunneoli, puberuli, pilis densis stellatis ca 0.1 mm longis; lamina 30–50 cm longa, 20–35 cm lata, ovata, atrovirens, pinnato-pinnatifida, sine pinna terminali distincta; pinnae 9–14-jugae, oppositae usque subopppositae, sessiles vel infimae minus quam 1 mm petiolulatae, usque ad 20 cm longae, 2.7 cm latae, latitudine ca 0.5–0.6-incisae, 2 vel 3 paribus infimis reflexis et basim versus leviter angustatis, aliquantum brevioribus quam mediis; segmenta obliqua, subfalcata, apice rotundata; rhachis, costae, costulae, venae, et pagina inter venas utrinque pubescentes pilis stellatis vel furcatis 0.1–0.2 mm longis, densissimis secus costas rachimque et paucis setis simplicibus longioribusque quam pilis (praesertim supra in venis et costis); venae 9–12-jugae, simplices, pari basali ad sinum conniventi vel angulo acuto infra sinum anastomosanti, venula ad sinum excurrenti; sori mediales usque supramediales, indusio



Figs. 1–3. *Thelypteris hatchii* (*Hatch & Wilson 159*). Fig. 1. Apical portion of frond. Fig. 2. Basal pinnae. Fig. 3. Abaxial surface of pinnules. Figs. 4–5. *Thelypteris cheilanthoides* var. *mucosa* (*Smith 451*). Fig. 4. Abaxial surface of pinnules. Fig. 5. Pinna from lower portion of frond. Fig. 6. *Thelypteris sanctiformis* (*Smith 462*).

persistenti, parvo, pubescenti pilis simplicibus furcatisque 0.1 mm longis; sporangia glabra.

✓TYPE: Senahu, Cerro Sillab, Alta Verapaz, Guatemala, 27 Jul 1936, *Hatch & Wilson 159* (US–2 sheets, part of the same frond).

ADDITIONAL SPECIMENS EXAMINED:

GUATEMALA: Alta Verapaz: Quebradas Secas, 2500 ft, 19 Oct 1920, *Johnson 850* (US). **MEXICO: Chiapas:** Without further locality, *Münch 45* (DS). **Oaxaca:** Dto. Choapam, ridge between Lovani and La Selva, 4500–5000 ft, 3 Dec 1971, *Hallberg 1599* (NY, UC); Ixtlán–Tuxtepec road, 35–39 km S of Valle Nacional, 4500–5200 ft, 27 Jul 1964, *Mickel 1547* (US); Dto. Ixtlán, 79 km N of Ixtlán de Juárez on Rte 175, 1 km S of Campamento Vista Hermosa, 4600–3850 ft, 27 Jul 1971, *Mickel 5634* (NY), *5668* (NY), *5670* (NY); Dto. Tuxtepec, 4–9 km S of Valle Nacional on Rte 175, 800–2200 ft, 31 Jul 1971, *Mickel 5899* (NY), *5900* (NY), *5913* (NY). **Veracruz:** Around Catemaco, *de la Sota 4017* (US).

This species is most likely to be confused with *Thelypteris biolleyi* (Christ) Proctor. These are the only two species known from Mexico that have densely stellate-pubescent costae and veins below. In addition to the character given in the key, *T. hatchii* differs from *T. biolleyi* in the generally smaller fronds with shorter pinnae, the lower pinnae lobed to the base (cuneate base in *T. biolleyi*), and the medial to supramedial sori (inframedial in *T. biolleyi*).

A chromosome count from *Mickel 5900* indicates that *T. hatchii* is diploid, $n = 36$.

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Thelypteris munchii A. Reid Smith, sp. nov. Figs. 9 and 10

Rhizoma erectum vel suberectum, basibus stipitum veterum et radicibus ca 1.5 mm crassis absconditum, ad apicem paleis castaneis glabris vestitum; frondes subdimorphae, fertiles stipitibus ca 30 cm longis, steriles stipitibus ca 15–20 cm longis; stipes brunneolus dilute purpureus puberulus, pilis stellatis ca 0.1 mm longis, glabrescens; rhachis dense stellato-pilosa, pilis ca 0.1 mm longis; lamina fertilis ovato-lanceolata, ca 25 cm longa, 10 cm lata, pinnato-pinnatifida (apex non visus, probabiliter pinnatifidus), sterilis ovata, ca 30 cm longa, ca 10 cm lata, pinnis infimis longissimis arcuatis, 3 vel 4 paribus infimis deflexis; pinnae fertiles ca 1.0(1.2) cm latae, latitudine usque 0.8-incisae, steriles usque ad 2.3 cm latae, latitudine ca 0.8–0.9-incisae; segmenta basilaria basiscopica pinnis infimis reducta, acroscopica non reducta segmentis distalibus similia vel leviter grandiora; costae supra pilosae, infra frondibus fertilibus sterilibusque pilosae pilis plerumque simplicibus ca 0.1 mm longis; costulae, venae, et pagina inter venas supra glabrae, infra frondibus fertilibus pilosae pilis ut in costis, frondibus sterilibus glabrae; venae simplices, pinnis fertilibus usque 7-jugae, pinnis sterilibus usque 10-jugae, infimis marginem sinus attingentibus non conniventibus vel vena distali paris contigui in frondibus sterilibus marginem supra sinum attingenti; sori mediales, indusio dense piloso, pilis ca 0.1 mm longis; sporangia glabra.

✓TYPE: Chiapas, Mexico, *Münch s.n.* (DS 267898; isotype DS 267898, sheet 2).

Thelypteris munchii differs from all other known species of subg. *Goniopteris* from Mexico and Central America in its densely short-pubescent indusia, the hairs being simple. Its nearest relatives are probably *T. resiliens* (Maxon) A. Reid Smith and *T. blanda* (Fée) Reed, which *T. munchii* resembles in general habit and rachis and costal pubescence. It can be easily distinguished from *T. resiliens* by the characters given in the key; from *T. blanda* it differs in the presence of an indusium, and the larger and somewhat dimorphic fronds.

This species honors German Münch, an assiduous collector of Chiapas ferns in the early 1900's.

Thelypteris (Goniopteris) resiliens (Maxon) A. Reid Smith, comb. nov.

Dryopteris resiliens Maxon, Field Mus. Nat. Hist., Bot. Ser. **17:** 302. 1938.

In addition to the single Mexican specimen cited by Maxon, I have seen two others, both from Chiapas: 41 km NW of Ocozocoautla, *Roe, Roe, & Mori 907* (US); and Km 40, S of Sureste, road to Mal Paso, *Roe, Roe, & Mori 1397* (US).

Thelypteris (Goniopteris) biolleyi (Christ) Proctor

SPECIMENS EXAMINED:

MEXICO: Chiapas: Cacahuatan, 550 m, *Fisher 35395* (US-3); *Purpus 7256* (UC, US); Esperanza, Escuintla, *Matuda 17959* (US); Finca Mexiquito, *Purpus 6736,* pt (US). **Oaxaca:** Dto. Villa Alta, ca 20 mi N of Villa Alta, Jul 1962, *Mickel 1031* (NY).

This species has not previously been reported from Mexico.

Thelypteris (Goniopteris) imbricata (Liebm.) Reed

SPECIMENS EXAMINED:

MEXICO: Guerrero: Dto. Galeana, Carrizo–Sto. Domingo, *Hinton et al. 14704* (GH, NY, US). **Jalisco:** Puerto Vallarta, *Mexia 1310* (CAS, DS, GH, NY, UC, US). **Oaxaca:** 5 km N of Matías Romero, route 185, *King 800* (MICH, US). Dto. Tuxtepec and into Dto. Teotitlán del Camino, *Hallberg 1339* (NY), *1340* (NY, UC); Dto. Juchitán, rte. 185 ca 35.5 km S of road to Jesus Carranza, *Cruden 1116* (UC); Dto. Pochutla, 29.6 km NE of Pochutla, *Mickel 1294* (MICH, US); Vicinity of Cafetal Concordia, *Morton & Makrinius 2545* (US). **Veracruz:** Santa Lucrecia, Isthmus de Tehuantepec, *C. L. Smith 2053* (GH); along Río Altonga near Pueblo Nuevo, *Reeder & Reeder 1950* (US); Tezonapa, between Cordoba and Tierra Blanca, *Carlson 1302* (US).

This species has usually been considered a synonym of *T. tetragona,* to which it is indeed closely related. Christensen (1913) included it under his *Dryopteris tetragona* var. 2. In addition to the characters given in the key, the two species also apparently differ in chromosome number; *T. imbricata* is diploid with $n = 36$, but *T. tetragona* is tetraploid (Smith, 1971a). Spore size appears to be correlated with ploidy in these two species, with *T. imbricata* having somewhat smaller spores.

Thelypteris subg. Amauropelta (Kunze) A. Reid Smith, stat. et. comb. nov.

Amauropelta Kunze, Farnkr. **1:** 86, 109. 1843. TYPE: *Amauropelta breutelii* Kunze [= *Thelypteris limbata* (Swartz) Proctor].

Oochlamys Fée, Gen. Fil. 297. 1852. TYPE: *Oochlamys rivoirei* Fée.

Dryopteris subg. *Lastrea sensu* C. Chr. Biol. Arb. til. Eug. Warm. 79. 1911, and *sensu* Christensen, 1913. Based on *Lastrea* Bory.

Thelypteris subg. *Lastrea sensu* Alston, J. Wash. Acad. Sci. **48:** 232. 1958. Morton, Amer. Fern J. **53:** 149–154. 1963.

Because *Lastrea* Bory was a superfluous name when published (Holub, 1969, p. 45, a new subgeneric name is needed for the New World species of *Thelypteris* with free veins and decrescent lamina. Delimitation of the natural subgroups within subg. *Amauropelta* is currently in progress, and I defer additional comments on circumscription until later.

KEY TO MEXICAN THELYPTERIS SUBG. AMAUROPELTA

1. Indusia absent.
   2. Sori elongate along the veins.
      3. Lowermost veins meeting the margin at or near the sinus; leaf tissue below glabrous or very sparsely hairy; pinnae incised to within ca 2 mm of the costae.
         T. linkiana (Presl) Tryon
      3. Lowermost veins meeting the margin above the sinus; leaf tissue below with hamate hairs; pinnae incised to within ca 1 mm of the costae.
         T. atrovirens (C. Chr. in Christ) Reed
   2. Sori round or nearly so.
      4. Hairs fasciculate on the costae and rachis below, appearing stellate; red, hemispherical glands present on leaf tissue below; aerophores at base of costae up to 4 mm long.
         T. thomsonii (Jenm.) Proctor
      4. Hairs not fasciculate and not appearing stellate; red, hemispherical glands absent; costal aerophores absent or less than 1 mm long.
         5. Sporangia minutely setose; costae and rachis below minutely puberulous, the hairs much less than 0.1 mm long.....*T. concinna* (Willd.) Ching
         5. Sporangia glabrous; costae and rachis below not minutely puberulous.
            6. Costae below with at least a few scales, especially near the base of the pinnae, the scales more or less clathrate.
               7. Hairs on the costae below more or less antrorse, mostly less than 0.6 mm long; receptacular tissue glabrous or with a few short hairs; pinnules somewhat oblique, rounded or acute.....*T. rudis* (Kunze) Proctor
               7. Hairs on the costae below mostly erect, up to 1.5 mm long; receptacular tissue with stiff hairs like those of the costae; pinnules more or less perpendicular to the costae, rounded at the tip.....*T. piloso-hispida* (Hook.) Alston
            6. Costae below without scales.
               8. Rachis rather densely short-hairy; stiff hairs on costules and veins above.
                  T. oligocarpa (Humb. & Bonpl. ex Willd.) Ching
               8. Rachis glabrous; costules and veins above glabrous.....*T. deflexa* (Presl) Tryon
1. Indusia present.
   9. Red or orange, sessile, hemispherical glands present on the leaf tissue below or on the indusia (or both); hairs on the leaf tissue and veins not hamate.
      10. Hairs on the costae and rachis below fasciculate, appearing stellate; costal aerophores up to 4 mm long.....*T. thomsonii* (Jenm.) Proctor
      10. Hairs not fasciculate, not appearing stellate.
         11. Rhizome creeping; costae below glabrous or sparsely hairy; glands present on indusia only.....*T. mortonii* A. Reid Smith
         11. Rhizome erect; costae below pubescent, sometimes sparsely hairy; glands present on indusia and/or lamina below.
            12. Sori submarginal, often partially hidden by the revolute leaf margin; a few septate hairs present on the costae and rachis below (rarely absent); veins immersed below, often darkened; basal basiscopic segment of well developed pinnae longer than the others, parallel to rachis.
               T. cheilanthoides (Kze.) Proctor
            12. Sori more or less medial on the veins, not hidden by the margin; septate hairs absent (except in some specimens of *T. balbisii* and *T. resinfera*); veins not immersed below, usually slightly raised, not darkened; basal basiscopic segment of pinnae not elongate parallel to the rachis.
               13. Two to four pairs of lower pinnae reduced; rachis and stipe darkened; rachis minutely but uniformly puberulous, the hairs less than 0.1 mm long.
                  T. sanctiformis (C. Chr.) Reed
               13. Five or more pairs of lower pinnae reduced; rachis stramineous, glabrous or sparsely hairy, the hairs flexuous and sometimes septate.

14. Pinna segments oblique with respect to the costa, usually falcate; pinnae gradually reduced nearly to the base of the frond; pinna segments mostly 2–3 times as long as broad.....*T. resinifera* (Desv.) Proctor
14. Pinna segments more or less perpendicular to the costa, not falcate; pinnae usually abruptly reduced with widely spaced smaller pinnae below; pinna segments mostly 4–6 times as long as wide.....*T. balbisii* (Spreng.) Ching

9. Red or orange, sessile, hemispherical glands absent on the leaf tissue below and on indusia; hamate hairs present or absent.
15. Rachis and stipe glabrous or nearly so.
16. One to four pair(s) of reduced pinnae below.....*T. tablana* (Christ) A. Reid Smith
16. Five or more pairs of reduced pinnae below.
17. Fronds very large, the pinnae 15–30 cm long and 2–4 cm wide; veins often darkened below.....*T. cheilanthoides* var. *mucosa* A. Reid Smith
17. Fronds small or of moderate size, the pinnae less than 15 cm long and less than 2 cm wide.
18. Indusia relatively large, persistent, glabrous; pinnules oblong, rounded at the tip, slightly oblique, not falcate.....*T. oaxacana* A. Reid Smith
18. Indusia rather small, often obscure in mature sori, glabrous or with a few hairs; pinnules linear, obtuse to acute at the tip, usually falcate.
T. resinifera (Desv.) Proctor

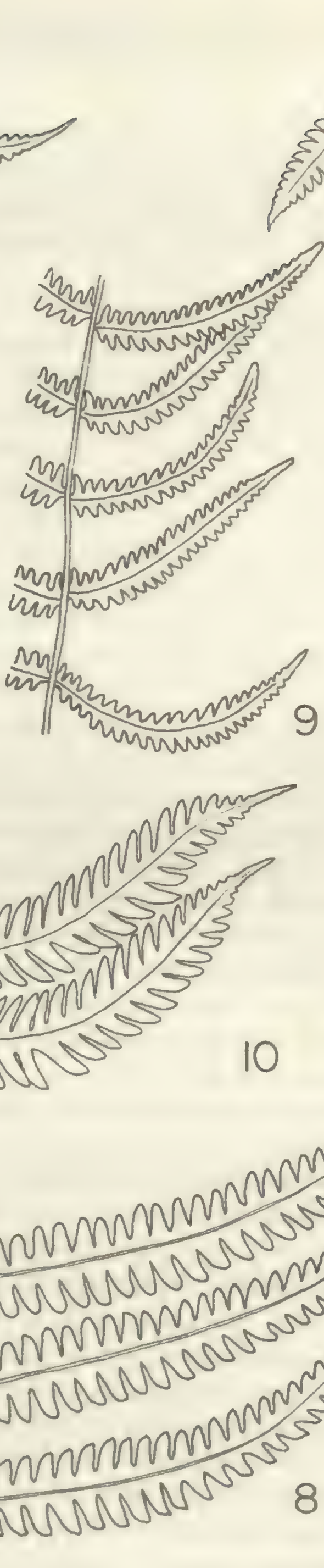
15. Rachis and stipe hairy.
19. Rachis hairs up to 1.5 mm long, stiff.....*T. pilosula* (Mett.) Tryon
19. Rachis hairs mostly short, mostly less than 0.3 mm long, or, if longer, flexuous.
20. Hamate hairs absent on the leaf tissue below and on the indusia.
T. resinifera (Desv.) Proctor
20. Hamate hairs present on the leaf tissue below and/or the indusia.
21. Reduced pinnae usually 2–4 pairs; rachis often darkened, densely hairy, the hairs 0.1–0.2 mm long with a few longer ones intermixed.
T. oligocarpa (Humb. & Bonpl. ex Willd.) Ching
21. Reduced pinnae more than 5 pairs, nearly to the base of the frond; rachis stramineous, not densely hairy.
22. Indusia dark-castaneous to blackish; rachis buds absent.
T. melanochlaena (C. Chr.) Reed
22. Indusia stramineous or light brown; rachis bud(s) present (in Mexican specimens).....*T. scalaris* (Christ) Alston

Thelypteris cheilanthoides var. mucosa A. Reid Smith, var. nov. Figs. 4–5

Rhizoma et stipites usque ad 5 cm diametro; rhizoma erectum, basibus stipitum usque ad 1 cm diametro absconditum; frondes usque ad 2 m longae vel aliquantum longiores; frondes volutae mucosae; stipes, rhachis, et costae glabrae praeter paucas paleas basi stipitis et secus costas infra; lamina vivens subsucculenta, exsiccata subcoriacea, venis nec supra nec infra elevatis, saepe immersis et denigricantibus; pinnae usque 40-jugae, mediae usque ad 30 cm longae, 4 cm latae, fere ad costam incisae, ala costali 0.5–3.0 mm lata, 2–5 paribus basalibus abrupte deminutis; segmenta recta vel subfalcata margine revoluta vel plana; costulae, venae et pagina inter venas utrinque glabrae vel infra glandibus flavis-aurantiacis brevistipitatis; venae usque 23-jugae; sori submarginales, indusiis persistentibus glabris; $n = 58$.

TYPE: Dto. Ixtlán, along road from Ixtlán to Tuxtepec, Km 126–129, ca 6200 ft., Oaxaca, Mexico, 28 Oct 1969, *A. R. Smith 451* (UC; isotypes to be distributed). *Mickel 4317* (NY) was collected at the same time and place.

7



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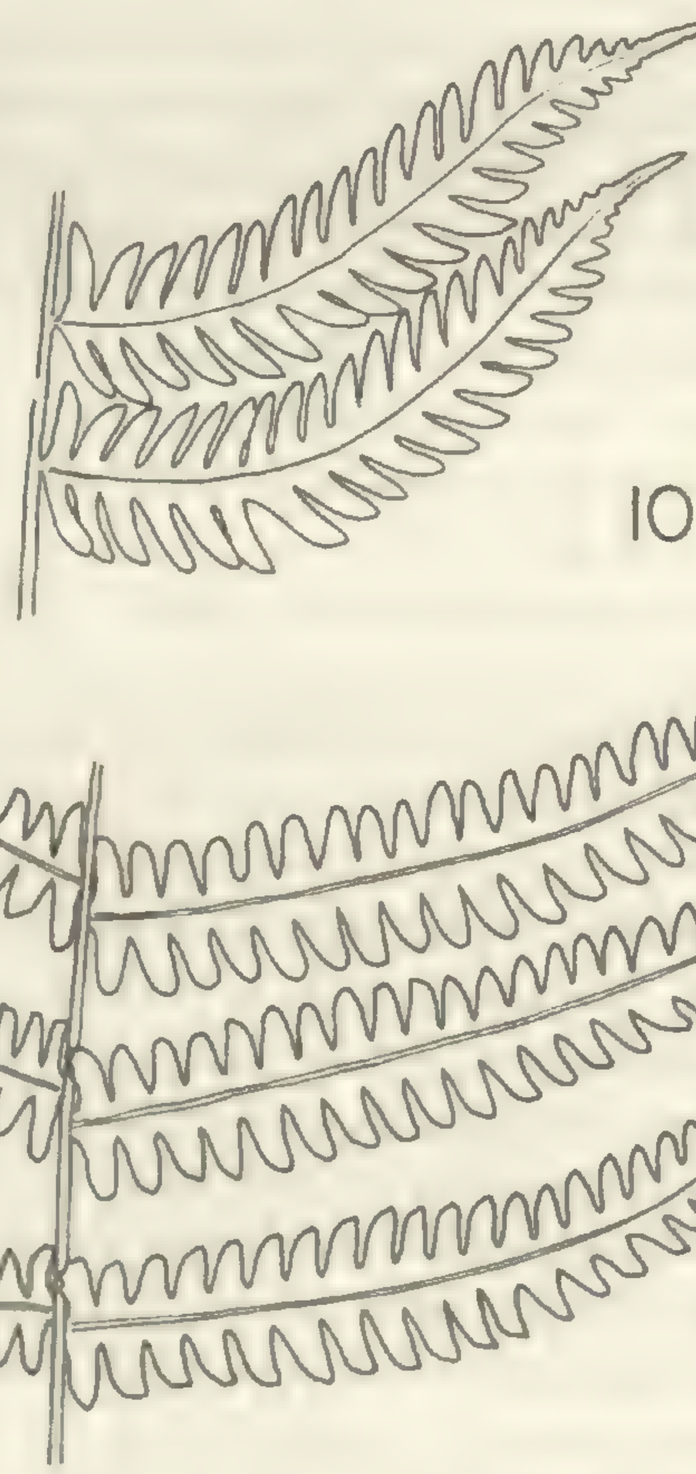

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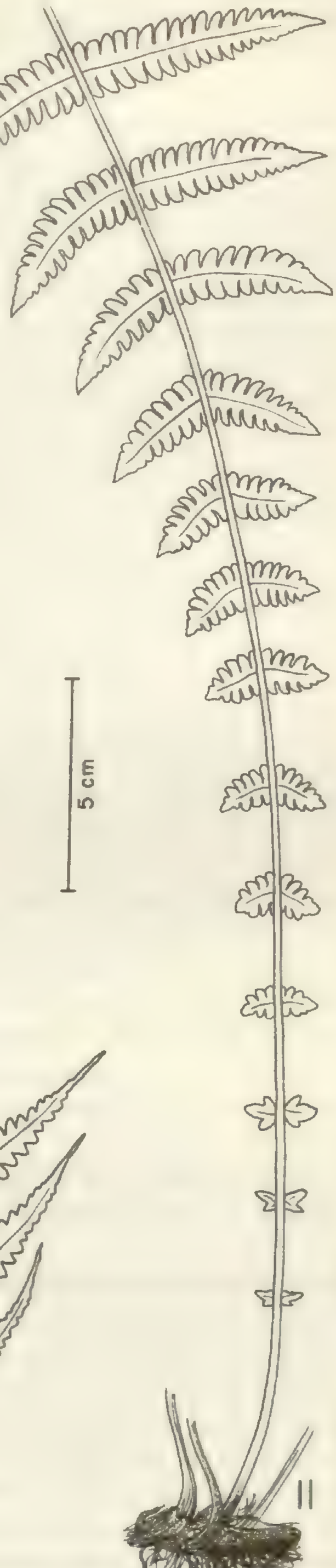

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Figs. 7–8. *Thelypteris oaxacana* (*Smith 459*). Fig. 7. Proximal portion of frond. Fig. 8. Medial pinnae. Figs. 9–10. *Thelypteris munchii* (*Münch s.n.*). Fig. 9. Proximal pinnae of fertile frond. Fig. 10. Proximal pinnae of sterile frond. Fig. 11. *Thelypteris mortonii* (*Sanchez 38*). Rhizome and basal portion of frond.

ADDITIONAL SPECIMENS EXAMINED:

MEXICO: Chiapas: Between Zinacantán and Chamula along road to Zinacantán Center, *Breedlove & Raven 8127* (DS). **Puebla:** Vicinity of Puebla, *Arsène 1935* (US). **Oaxaca:** Dto. Ixtlán, along road from Ixtlán to Tuxtepec, Km 126–129, *A. R. Smith 461* (UC), *463* (UC). **Veracruz:** La Perla, *Herb. Copeland 31* (GH, UC, US); Tatzallanala, Municipio Atzalán, *Ventura 229* (NY).

The type of var. *mucosa* is from a very large plant with fronds nearly 8 feet long. The lamina and veins below are completely without hairs, even on young fronds. Specimens of var. *cheilanthoides* are always at least sparingly pubescent, the hairs usually septate. The young croziers are covered with a thick layer of mucilage, a feature found in several species of *Thelypteris,* most notably those related to *T. resinifera* and *T. cheilanthoides.*

Chromosome counts on the type plant and another plant from the type locality (*Smith 463*) indicate that var. *mucosa* is tetraploid with $n = 58$. All counts so far made of the type variety are diploid (Smith, 1971a).

Figs. 7–8

Thelypteris oaxacana A. Reid Smith, sp. nov.

Rhizoma erectum; frondes ca 60–95 cm longae, 14–25 cm latae, pinnis (6)7–10-jugis basim versus gradatim reductis deflexisque; frondes volutae mucosae; stipes stramineus vel dilute brunneolus, usque ad 15 cm longus, basi 5 mm diametro; rachis supra pilis secus sulcum dispersis, infra glabra; pinnae oppositae vel suboppositae, apicales interdum alternae, 1.3–2.1 cm latae, basi latissimae, latitudine ca 0.8-incisae; segmenta ca 3–5 mm lata, leviter obliqua non falcata, apice rotundata vel subacuta; costae supra pilis dispersis 0.5 mm longis, infra epilosae, et basim versus paucis paleis lineari-lanceolatis stramineis et aerophoris brevibus protrudentibus; costulae supra sicut costae, infra glabrae; venae et pagina inter venas utrinque glabrae, eglandulosae; venae 5–7(8)-jugae, infimae marginem supra fundum ipsum sinus attingentes; sori mediales, rotundi vel leviter oblongi, indusiis ca 0.7 mm diametro; sporangia glabra.

TYPE: N of Oaxaca, Ixtlán–Tuxtepec road, Km 126–129, ca 6200 ft, 28 Oct 1969, Oaxaca, Mexico, *A. R. Smith 459* (UC).

ADDITIONAL SPECIMENS EXAMINED:

EL SALVADOR: Chalatenango: E slope of Los Esesmiles, 2100–2150 m, 14 Mar 1942, *Tucker 1043* (MICH). **MEXICO: Chiapas:** Municipio Tuzantán, ca 15 km NE of Huixtla, *Breedlove & Smith 22845* (DS). **Oaxaca:** Ixtlán–Tuxtepec road, Km 126–129, *A. R. Smith 460;* Ixtlán–Tuxtepec road, Km 134, *A. R. Smith 403;* road from Oaxaca to Tuxtepec, Km 112–127, *Hellwig 322* (NY).

Thelypteris oaxacana belongs to the group of *Thelypteris pachyrachis* on the basis of its relatively large, persistent indusia, glabrous fronds, and oblong pinna segments. It differs from *T. pachyrachis* in the absence of sessile, red glands on the lamina and indusia. From *T. resinifera* it differs in the glabrous lamina, absence of glands, broader segments that are rounded at the tip, and fewer and more widely spaced, reduced lower pinnae.

Fig. 11

Thelypteris mortonii A. Reid Smith, sp. nov.

Rhizoma breviter repens, usque ad 8 mm diametro, ca 8 frondibus per 5 mm; frondes 60–95 cm longae, 9–13 cm latae, pinnis usque 50-jugis; stipes stramineus, basi fuscatus et paucis paleis pallide brunneis adpressis glabris, 3–10 cm longus,

basi usque ad 4 mm diametro; lamina papyracea, basim versus gradatim reducta; rhachis straminea, supra secus sulcum glabra infra pilosa; pinnae usque ad 1.6 cm latae, aequilaterae, latitudine ca 0.8–0.9-incisae, oppositae vel subopppositae, mediae longissimae, 10–20 basales gradatim reductae, infimae steriles; segmenta usque 25-juga, usque ad 8 mm longa, 2–3 mm lata, anguste oblonga non falcata, leviter obliqua, margine plana apice rotundata vel subacuta, contigua imbricata vel sinu perangusto basi acuto separata; segmenta basalia leviter longiora latioraque quam distalia, ad rhachim plus minusve parallela, margine integra vel leviter crenata, saepe super rhachim imbricata; costae, costulae, et venae utrinque pilis dispersis ca 0.2 mm longis, sine paleis; venae et pagina inter venas infra glandulis aurantiacis sessilibus dispersis; pagina inter venas supra modice pilis dispersis; venae simplices, plerumque 6–9-jugae, infimae marginem supra sinum attingentes; sori supramediales usque submarginales, indusio parvulo epiloso saepe glandulis sessilibus aurantiacis-rubris abscondito; sporangia glabra.

TYPE: Bosencheve, 1750 m, Sept 1943, Mexico, Mexico, *Sanchez 38* (US 1843067; isotypes: US–3, UC).

ADDITIONAL SPECIMENS EXAMINED:

MEXICO: Jalisco: Near Guadalajara, 5000 ft, *Pringle 11794* (MICH). **Mexico:** Bosencheve, 1500 m, *Sanchez 65* (US). **Morelos:** Lagunas de Zempoala, 2800 m, Sept 1941, *Lyonnet & Chavez 3390* (US).

This species is named in honor of C. V. Morton, who first suggested to me that it might be distinct. It is, in fact, one of the more easily recognized species of *Thelypteris* in Mexico, belonging to the group of *Thelypteris opposita* (Vahl) Ching and *T. resinifera* (Desv.) Proctor. It differs from the latter in the small indusia completely obscured by orange-red glands, in the nearly glabrous axes below, in the creeping rhizome, in the more narrowly ovate-lanceolate blade outline, in the less oblique, non-falcate pinna segments, and in the sori located closer to the margin of the segments.

Thelypteris (Amauropelta) atrovirens (C. Chr. in Christ) Reed

SPECIMENS EXAMINED:

MEXICO: Chiapas: Palenque, *Münch 50*(?) (DS). **Oaxaca:** Dto. Villa Alta, valley of Yelagago River, ca 20 mi NE of Villa Alta, 4300 ft, 26 Jul 1962, *Mickel 986* (MICH).

Not previously reported from Mexico.

Thelypteris (Amauropelta) deflexa (Presl) Tryon

SPECIMENS EXAMINED:

MEXICO: Chiapas: *Breedlove & Smith 21999* (DS). **Oaxaca:** N of Oaxaca along road from Ixtlán to Tuxtepec, Km 126–129, ca 6200 ft, 28 Oct 1969, *Smith 450* (UC), *454* (UC); Ixtlán–Tuxtepec road, Km 123, 6650 ft, 23 Oct 1969, *Smith 402* (UC); Ixtlán–Tuxtepec road, Km 119, 6600 ft, 27 Oct 1969, *Smith 432* (UC), *436* (UC), *437* (UC); Dto. Cuicatlán, Jun 1898, *Gonzalez & Conzatti 732* (GH); El Fortín, Cerro de San Felipe, Sept 1898, *Gonzalez & Conzatti 912* (GH); Dto. Villa Alta, Yelagago River Valley, ca 20 mi NE of Villa Alta, 26 Jul 1962, *Mickel 985* (NY), *986* (ISC); Dto. Teotitlán, 26–29 km NE of Teotitlán del Camino, 7000–7400 ft, 16 Oct 1969, *Mickel 4110* (NY); Dto. Ixtlán, Cerro de Malacate, N of Capulalpan, ca 8 km E of Ixtlán, 5 Oct 1970, *Mickel 5261* (NY); Dto. Ixtlán, 65 km N of Ixtlán de Juárez, 6400 ft, 25 Jul 1971, *Mickel 5572* (NY). Dto. Ixtlán, 52 km N of Ixtlán de Juárez on Rte 175, 7800 ft, 25 Jul 1971, *Mickel 5603* (NY).

Not previously reported from Mexico.

This species had been known previously from only as far north as Costa Rica. For this reason, I at first thought that the numerous collections from southern Mexico might represent an undescribed species. Mexican collections are indeed slightly more pubescent on the costae below than material I have seen from Honduras, Costa Rica, and Peru, and in this respect approach very closely *Dryopteris sellensis* C. Chr. from Hispaniola. If the latter species is regarded as distinct, Mexican specimens fall within its circumscription.

Several plants of *T. deflexa* from Oaxaca have recently been counted as $n = 58$ (Smith, 1971a) and reported as *T.* cf. *tablana,* a species that resembles *T. deflexa* in blade size, cutting, and general lack of pubescence, but differs in being indusiate. *Mickel 5603* is also $n = 58$.

Thelypteris (Amauropelta) sanctiformis (C. Chr.) Reed Fig. 6

SPECIMENS EXAMINED:

MEXICO: Chiapas: Puerto Viendo, near Rincón Chamula, 60000 ft, *Gittins 4180* (NY-2). **Oaxaca:** Ixtlán–Tuxtepec road, Km 126–129, N of Oaxaca, 6200 ft, *Smith 462* (UC).

Thelypteris sanctiformis has previously been reported from Guatemala, Panama, Venezuela, and Ecuador, but not from Mexico. The Mexican collections agree well with the type, which is from Panama.

A chromosome count from *Smith 462* indicates that *T. sanctiformis* is diploid, $n = 29$.

Thelypteris (Amauropelta) thomsonii (Jenm.) Proctor

SPECIMEN EXAMINED:

MEXICO: Oaxaca: About 15 km E of Ixtlán, near Natividad, along trail leading to Llano Verde, *Smith 499* (UC).

This is the first report of this species from Mexico.

Thelypteris (Amauropelta) tablana (Christ) A. Reid Smith, comb. nov.

Aspidium tablanum Christ, Bull. Herb. Boiss. II, **5:** 727. 1905. TYPE: San Pablo, Chiapas, Mexico, *Münch 146* (P; isotype DS).

Known only from the type collection.

LITERATURE CITED

CHRISTENSEN, C. 1913. A monograph of the genus Dryopteris. Part I. The tropical American pinnatifid-bipinnatifid species. K. Danske Vidensk. Selsk. Skr. VII, **10:** 55–282.

HOLUB, J. 1969. Oreopteris, a new genus of the family Thelypteridaceae. Folia Geobot. Phytotax., Praha **4:** 33–53.

MAXON, W. R. and C. V. MORTON. 1938. The American species of Dryopteris, subg. Meniscium. Bull. Torr. Bot. Club. **65:** 347–376.

SMITH, A. R. 1971a. Chromosome numbers of some New World species of Thelypteris. Brittonia **23:** 354–360.

————. 1971b. Systematics of the Neotropical species of Thelypteris section Cyclosorus. Univ. Calif. Publ. Bot. **59:** 1–136.

Ferns, Lichens, and Hummingbirds' Nests

RAMÓN RIBA and TEÓFILO HERRERA*

Birds often utilize fern scales or pinna fragments for building their nests. Many years ago, A. F. Skutch (Amer. Fern. J. **36:** 15–17. 1946) published a paper about this. More recently, Dr. C. B. Kepler wrote to us about the nests of an endemic Porto Rican hummingbird (*Chlorostilbon maugaeus*), which are made with the scales of the Tree-fern *Cyathea arborea.*

On a recent field trip to Xicotepec de Juárez, in the state of Puebla, we found two small birds' nests made with fern scales in a *Liquidambar* and *Quercus* forests. Both nests belonged to hummingbirds. It was not possible to collect the birds for identification purposes, but we would like to describe the nests.

The one nest, which was built on a *Verbesina,* was conical and about 6 cm high and 4 cm in diameter. The general frame, although fairly loose, was made entirely of the petiole scales of *Nephelea mexicana* (Schlecht. & Cham.) Tryon. These scales are structurally marginate, i.e., they have a narrow margin of cells that is different in orientation, size, and shape from those of the central portion of the scale. In addition, they have a dark seta at the apex and several more on the margins of the scale. Besides the scales, the nest shows on the upper, concave face many small, wooly fruits of bromeliads. The web-like construction made of the scales gives enough strength to the nest to support both the hummingbird and her eggs.

The other nest we found on a *Liquidambar* plant. It is cylindrical and about 5 cm high and 4 cm wide. It is built of hundreds of petiole scales of *Nephelea mexicana,* but its upper, concave end is covered with long hairs from the stipe bases or rhizomes of *Lophosoria quadripinnata* (Gmel.) C. Chr., which form a soft bed for the newly hatched birds.

Besides the petiole scales and hairs that form the body of the nests, there are also lichens of different species in the outer wall. The conical nest shows several specimens of *Cladonia sylvatica* (L.) Hoffm. and two small fragments of *Physcia* sp. or *Parmelia* sp. The cylindrical nest has several specimens of *Physcia setosa* (Ach.) Nyl. In the latter nest it is easy to suppose that the lichens have a camouflage purpose, rather than an ornamental one, because the twigs of the *Liquidambar* are almost covered with specimens of *Physcia setosa.*

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Phytogeography of the Pteridophytes in Peninsular Thailand[1]

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The pteridophytes of Thailand have recently been studied intensively in the course of the Flora of Thailand project. I have participated in this project and have enumerated some 620 species of pteridophytes from this country. Concerning the phytogeography of Thailand, I have already discussed the species known from the northern part of this country, with special reference to the pteridophytes (Iwatsuki, 1972). It was concluded in that paper that northern Thailand belongs to the extreme southernmost part of the Sino-Himalayan region; the pteridophytes of peninsular Thailand, on the contrary, belong to the Malaysian phytogeographical element. At the beginning of this century, Ridley in 1913 and in several other papers published on the phytogeography of northern Malaya and lower Siam, chiefly based upon his own field observations; his data, however, are insufficient to compare with those available at present. In his comprehensive book on Malayan ferns, Holttum (1954) noted the distribution of Malayan ferns in lower Siam.

In the course of my floristic research on Thai pteridophytes, I have checked most of the herbarium specimens of pteridophytes collected from Thailand and have made field surveys in that country, as well as in Malaya, northern Sumatra, and the Himalayas, for purposes of making comparisons. In this paper I will treat the same topics as I did in my previous paper on the phytogeography of northern Thailand.

Pattani.—I have published a checklist of the pteridophytes collected in Changwat Pattani, Yala, and Narathiwat (Tagawa & Iwatsuki, 1968). Usually these three Changwat (Provinces) are collectively called "Pattani" in the older sense. I myself have never been in this area; my paper was based mostly on the collections (preserved in BK and SING) of A. F. G. Kerr and E. Smith, who made a detailed exploration of this area.

H. N. Ridley also conducted botanical research in this area. He concluded that the main phytogeographical boundary between Malaya and Thailand was just on the line between Kota Bharu and Perlis, which is similar to the contemporary national border between Thailand and Malaya. At that time Ridley wished to distinguish the Malayan elements from the Burmese; his discussion on this topic was mostly based on the flowering plants. Holttum did not concern himself with the problem of the phytogeographical boundary, although he frequently noted that the ferns of Malaya extended northwards to lower Siam, especially to Pattani, which included in his sense both Yala and Narathiwat.

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[1] My field studies in Thailand were made possible by financial support from the Ministry of Education, Japan, through the Center for Southeast Asian Studies, Kyoto University. We are indebted to the National Research Council at Bangkok and the Forest Herbarium, Royal Forest Department at Bangkok for making possible the botanical surveys in Thailand.

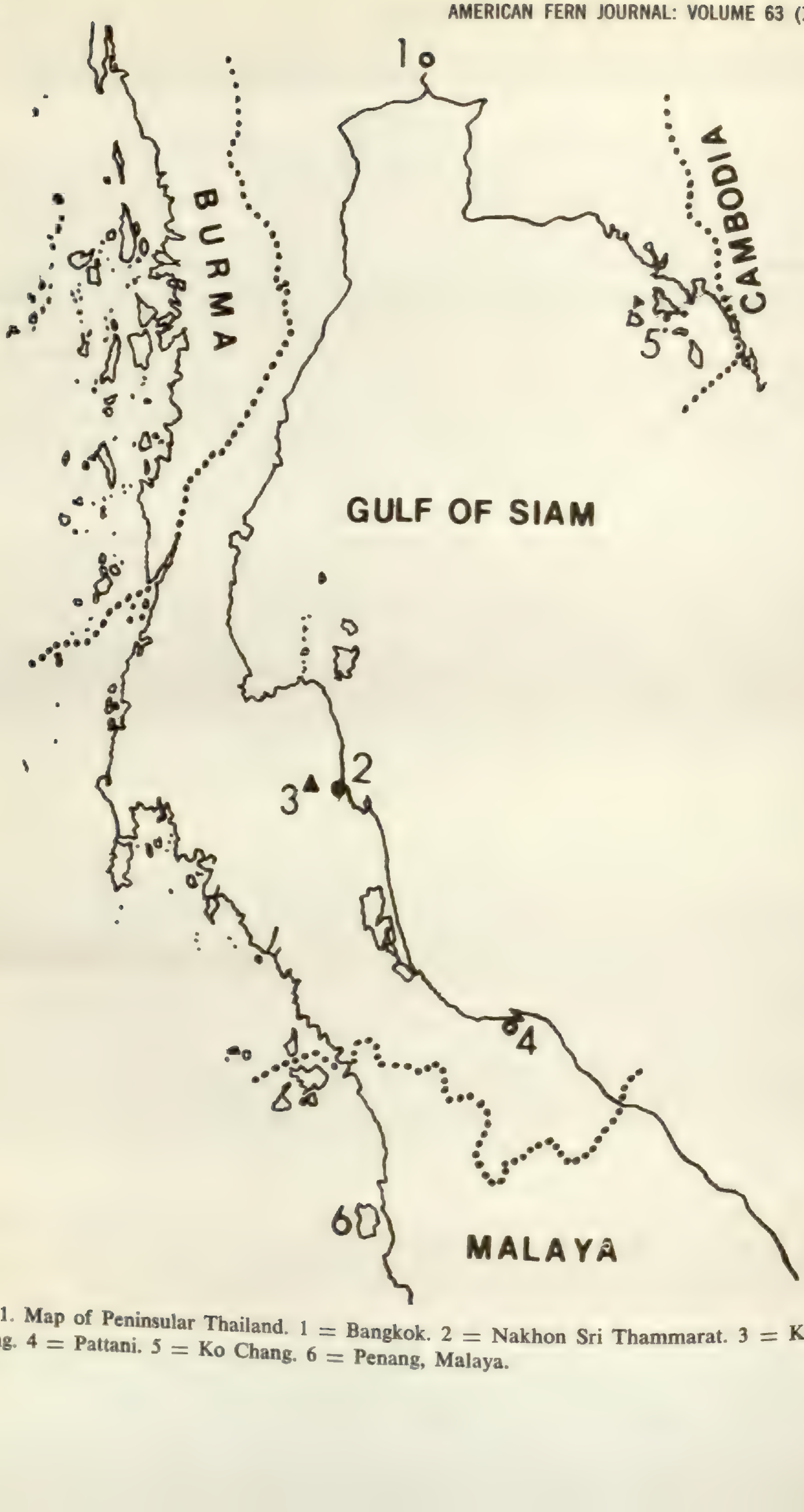

Fig. 1. Map of Peninsular Thailand. 1 = Bangkok. 2 = Nakhon Sri Thammarat. 3 = Khao Luang. 4 = Pattani. 5 = Ko Chang. 6 = Penang, Malaya.

The following list is of the additional species now known in these three Changwat, and does not include those already recorded by me in the 1968 publication:

Selaginella delicatula (Desv.) Alston, *S. intermedia* (Blume) Spring, *S. roxburghii* (Hook. & Grev.) Spring, *S. strigosa* Bedd., *S. willdenovii* (Desv. ex Poir.) Baker, *S. wallichii* (Hook. & Grev.) Spring, *Helminthostachys zeylanica* (L.) Hooker, *Dicranopteris curranii* Copel., *D. linearis* (Burm.) Underw., *Schizaea dichotoma* (L.) J. E. Smith, *S. digitata* (L.) Swartz, *Lygodium polystachyum* Wall. ex Moore, *Gonocormus saxifragoides* (Presl) v. d. Bosch, *G. teysmannii* v. d. Bosch, *Cyathea gigantea* (Wall. ex Hook.) Holtt., *C. latebrosa* (Wall. ex Hook.) Copel., *Microlepia strigosa* (Thunb.) Presl, *Lindsaea doryphora* Kramer, *L. ensiformis* Swartz, *L. integra* Holtt., *L. lucida* Blume, *Tapeinidium pinnatum* (Cav.) C. Chr., *Davallia divaricata* Blume, *Humata heterophylla* (J. E. Smith) Desv., *Nephrolepis acuminata* (Houtt.) Kuhn, *N. biserrata* (Swartz) Schott, *N. hirsutula* (Forst.) Presl, *Oleandra pistillaris* (Swartz) C. Chr., *Taenitis blechnoides* (Willd.) Swartz, *Doryopteris ludens* (Wall. ex Hook.) J. Smith, *Cheilanthes belangeri* (Bory) C. Chr., *C. tenuifolia* (Burm.) Swartz, *Adiantum caudatum* L., *Antrophyum callifolium* Blume, *A. parvulum* Blume, *Vittaria ensiformis* Swartz, *Pteris blumeana* Agardh, *P. dalhousiae* Hooker, *P. ensiformis* Burm., *P. longipinnula* Wall. ex Agardh, *P. tripartita* Swartz,[2] *P. vittata* L., *Asplenium grevillei* Wall. ex Hook. & Grev., *A. nitidum* Swartz, *Blechnum orientale* L., *Bolbitis sinuata* (Presl) Hennip., *Teratophyllum aculeatum* (Blume) Mett. ex Kuhn, *Lomariopsis cochinchinensis* Fée, *Polystichum prolificans* v.A.v.R., *Tectaria melanocaulis* (Blume) Copel., *T. singaporeana* (Wall. ex Hook. & Grev.) Ching, *T. variolosa* (Wall. ex Hook.) C. Chr., *T. vasta* (Blume) Copel., *Heterogonium alderwereltii* Holtt., *H. gurupahense* (C. Chr.) Holtt., *H. pinnatum* (Copel.) Holtt., *Pleocnemia hemiteliifolia* (Racib.) Holtt., *Pteridrys australis* Ching, *P. syrmatica* (Willd.) C. Chr. & Ching, *Thelypteris arida* (Don) Morton, *T. ciliata* (Wall. ex Benth.) Ching, *T. crassifolia* (Blume) Ching, *T. exsculpta* (Baker) K. Iwats., *T. gongylodes* (Schkuhr) Small, *T. heterocarpa* (Blume) Morton, *T. immersa* (Blume) Ching, *T. menisciicarpa* (Blume) K. Iwats., *T. multilineata* var. *malayensis* (Holtt.) Tagawa & K. Iwats., *T. torresiana* (Gaud.) Alston, *Diplazium cordifolium* Blume, *D. riparium* Holtt., *D. simplicivenium* Holtt., *Platycerium coronarium* (König ex Müller) Desv., *Pyrrosia adnascens* (Forst.) Ching, *P. stigmosa* (Swartz) Ching, *Drymoglossum piloselloides* (L.) Presl, *Belvisia mucronata* (Fée) Copel., *Microsorium pteropus* (Blume) Copel., *Drynaria quercifolia* (L.) J. Smith, *D. rigidula* (Swartz) Bedd., *Loxogramme scolopendrina* (Bory) Presl, and *Ctenopteris mollicoma* (Nees & Blume) Kunze.

All of the species listed above are also native to Malaya. Many of them are absent in the area north of Changwat Pattani. Compared to the rich flora of Malaya, the number of pteridophytes in these Changwat, fewer than 200 species, may be small, but the species known to occur in this area show that southernmost Thailand belongs floristically to the area of Malaya, at least insofar as Changwat Pattani, Yala and Narathiwat are concerned.

Khao Luang.—There are several peaks in peninsular Thailand which receive daily mist, and Khao Luang is the highest among them. The altitude of this mountain is 1786 m; it is located at about 8°30′ N and 99°40′ E. or about 25 km west of Nakhon Sri Thammarat. This mountain has repeatedly been explored by various botanists who collected the pteridophytes, including A. F. G. Kerr. E. Smith, Tem Smitinand, Kai Larsen, B. Hansen, G. Seidenfaden, E. Hennipman, and others. I myself have been there twice, in January, 1966 and in August, 1967,

[2] *E. Smith et al 1911*, identified as *P. wallichiana* in the last enumeration, is this species; *P. wallichiana* should, therefore, be excluded from the 1968 list.

and have collected a comprehensive number of specimens. The identification list for the 1966 expedition was reported together with collections made in other localities in Thailand (Tagawa & Iwatsuki, 1967).

About 150 species were enumerated from Khao Luang in the list of our 1966 expedition, including those from Kiriwang, a village at the foot of the mountain lying at about 100 m altitude. On that trip we took seven days to botanize on the mountain. To compare the number of species, I can refer here to my recent botanical trip to northern Sumatra. There I visited Gunung Kemiri in Aceh for about a week and collected about 180 species of pteridophytes (Iwatsuki, 1973). Although Gunung Kemiri is more than 3000 m in altitude and the village at its foot, Kampung Geumpang, is at about 600 m above sea level, the vegetation on these two mountains is similar, except that the higher elevations of Gunung Kemiri are covered by ericoid forest.

I have now some 40 species to add to the list of Khao Luang pteridophytes, although I wish to compare here only the number of species collected in a single trip to that of the comparable mountain, Gunung Kemiri under the same conditions, for the floristic outline of Khao Luang may be seen in the 1967 enumeration. The flora is richest in the mossy forest, especially in the small epiphytes such as the filmy ferns and the grammitids. I also was in the Cameron Highlands of Malaya in 1967 and observed the vegetation there. Many species are common to these three areas, although some of them are different from each other. At the rank of genus, *Plagiogyria, Myriodon, Amphipterum, Monachosorum, Paesia, Selliguea,* and *Stegnogramma* are not found in Khao Luang, but are present on Gunung Kemiri.

Based on these data, it is concluded here that Khao Luang is a mountain floristically similar to the Cameron Highlands in Malaya and to Gunung Kemiri in northern Sumatra. These areas are similar to each other not only in their component species but also in their vegetational aspect. From this fact, we can refer the mountain Khao Luang safely to the Malaysian phytogeographic region.

Malaysian Elements.—More than 600 species of pteridophytes are known from Thailand, and some 400 of them are recorded from the peninsular area. Many tropical species of the so-called Malaysian element occur in the peninsular area. Here are enumerated the genera of the Asiatic-Oceanic tropics which range from Ceylon to Polynesia, including peninsular Thailand: *Microtrichomanes, Crepidopteris, Pleuromanes, Cephalomanes, Macroglena, Syngramma, Vaginularia, Teratophyllum, Heterogonium, Dipteris, Cheiropleuria, Photinopteris, Acrosorus, Calymmodon, Prosaptia,* and *Scleroglossum.*

More than 100 species of Thai pteridophytes have this type of distribution. These extend to central, southeastern and southwestern Thailand, but are absent from the region north of the central plain. Species representing the Malaysian distribution include:

Lycopodium piscium (Hert.) Tagawa & K. Iwats., *Selaginella willdenovii* (Desv. ex Poir.) Baker, *Gleichenia norrisii* Mett. ex Kuhn, *Dicranopteris curranii* Copel., *D. speciosa* (Presl) Holtt., *Mecodium productum* (Kunze) Copel., *Meringium acanthoides* (v. d. Bosch) Copel.,

Crepidomanes brevipes (Presl) Copel., *C. christii* (Copel.) Copel., *Cyathea contaminans* (Wall. ex Hook.) Copel., *Lindsaea oblanceolata* v.A.v.R., *Davallia corniculata* Moore, *Davallodes viscidulum* (Mett. ex Kuhn) v.A.v.R., *Humata vestita* (Blume) Moore, *Nephrolepis acuminata* (Houtt.) Kuhn, *Oleandra pistillaris* (Swartz) C. Chr., *Pteris scabripes* Wall. ex Hook., *Asplenium batuense* v.A.v.R., *A. longissimum* Blume, *A. salignum* Blume, *A. squamulatum* Blume, *Ctenitis vilis* (Kunze) Ching, *Tectaria maingayi* (Baker) C. Chr., *T. singaporeana* (Wall. ex Hook. & Grev.) Ching, *Pleocnemia hemiteliiformis* (Racib.) Holtt., *Thelypteris crassifolia* (Blume) Ching, *T. megaphylla* (Mett.) K. Iwats., *T. sumatrana* (v.A.v.R.) K. Iwats., *T. urophylla* (Wall. ex Hook.) K. Iwats., *T. viscosa* (J. Smith) Ching, *Diplazium bantamense* Blume, *D. cordifolium* Blume, *D. crenatoserratum* (Blume) Moore. *D. tomentosum* Blume, *D. xiphophyllum* (Baker) C. Chr., *Lemmaphyllum accedens* (Blume) Donk, *Microsorium heterocarpum* (Blume) Ching, *Loxogramme avenia* (Blume) Presl, *L. subecostata* (Hook.) C. Chr., *Crypsinus laciniatus* (Presl) Holtt., *C. trilobus* (Houtt.) Copel., *Polypodium persicifolium* Desv., *Grammitis jagoriana* (Mett.) Tagawa, *G. setosa* Blume, *Ctenopteris mollicoma* (Nees & Blume) Kunze, and *C. moultonii* (Copel.) C. Chr. & Tard.

Among the species of the Malaysian element, however, a considerable number of the ferns do extend northward beyond the central districts. Examples of this are:

Microgonium motleyi v. d. Bosch, *Selenodesmium obscurum* (Blume) Copel., *Cyathea latebrosa* (Wall. ex Hook.) Copel., *Microlepia puberula* v.A.v.R., *Lindsaea lucida* Blume, *Davallia divaricata* Blume, *Nephrolepis falcata* (Cav.) C. Chr., *Taenitis blechnoides* (Willd.) Swartz, *Pteris asperula* J. Smith ex Hieron., *P. tripartita* Swartz, *Asplenium paradoxum* Blume, *Arcypteris irregularis* (Presl) Holtt., *Thelypteris immersa* (Blume) Ching, *Pyrrosia floccigera* (Blume) Ching, *Pleopeltis longifolia* Blume, *Microsorium rubidum* (Kunze) Copel., and *Myrmecophila sinuosa* (Wall. ex Hook.) Ching.

The Malaysian elements generally do not belong to the more widely distributed genera which extend southward to New Zealand and Australia and northward to North India and/or Japan. Such Thai species with this distribution pattern are usually known throughout Thailand, and the genera with this type of distribution are: *Helminthostachys, Crepidomanes, Microgonium, Leucostegia, Taenitis, Brainea, Acrophorus, Diacalpe, Pteridrys, Christiopteris,* and *Leptochilus.*

Several species extend further west to tropical Africa; these palaeotropical species are usually found in Thailand throughout the country, such as:

Ophioglossum pendulum L., *Lygodium microphyllum* (Cav.) R. Br., *Gonocormus saxifragoides* (Presl) v. d. Bosch, *Crepidomanes bipunctatum* (Poir.) Copel., *Microlepia speluncae* (L.) Moore, *Lindsaea ensifolia* Swartz, *Sphenomeris chinensis* (L.) Maxon, *Ceratopteris thalictroides* (L.) Brongn., *Adiantum caudatum* L., *A. philippense* L., *Antrophyum calliforme* Blume, *Vittaria ensiformis* Swartz, *V. elongata* Swartz, *Pteris vittata* L., *Asplenium nidus* L., *A. normale* Don, *A. pellucidum* Lam., *A. unilaterale* Lam., and *Microsorium scolopendrium* (Burm.) Copel.

Among the species of this type of distribution, *Microtrichomanes digitatum* (Swartz) Copel. is confined to peninsular Thailand, and those not found as yet in the peninsular area are *Hypolepis punctata* (Thunb.) Mett. ex Kuhn, *Lindsaea odorata* Roxb., *Asplenium excisum* Presl, and *Hypodematium crenatum* (Forsk.) Kuhn.

The pantropical species that are commonly known throughout Thailand have no special phytogeographical importance.

The wide plain of central Thailand is like an ocean or desert for the pteridophytes, and many species of the Malaysian element are known only south of central Thailand in the peninsular area. However, there are several species of the so-called Malaysian element which do extend northward to northeastern or northern Thailand, and so it is very difficult to determine a sharp phytogeographical boundary. In Thailand we can set that boundary broadly on the central plain, including the southeastern portion in the northern tip of the Malaysian region. Concerning southwestern Thailand, it is impossible at present to give any phytogeographical boundary, and the species there seem to change rather gradually from south to north. There are a few species which extend northward along the mountains around the Thai-Burmese border, although it will be necessary to explore this area before drawing more definite conclusions about the phytogeography of Thailand.

LITERATURE CITED

HOLTTUM, R. E. 1954. Revised Flora of Malaya, vol. II. Ferns of Malaya. Gov't. Printing Office, Singapore.

IWATSUKI, K. 1972. Phytogeography of the pteridophytes in northern Thailand. Acta Phytotax. Geobot. **25:** 69–78.

————. 1973. Pteridophytes of Northern Sumatra—A report of botanical trip in 1971. Southeast Asian Stud. (In press).

RIDLEY, H. N. 1913. Botanical expedition to Lower Siam. Gard. Chron. **49:** 361–362, 383–384, 406–407.

TAGAWA, M. and K. IWATSUKI. 1967. Enumeration of Thai pteridophytes collected during 1965–66. Southeast Asian Stud. **5:** 23–120.

————, and K. IWATSUKI. 1968. New or interesting ferns from Thailand 2. Acta Phytotax. Geobot. **23:** 48–56.

————, and K. IWATSUKI. 1972. Families and genera of the pteridophytes known from Thailand. Mem. Fac. Sci. Kyoto Univ. Biol. **5:** 67–88.

Seven New Species of Selaginella from Tropical South America

J. A. CRABBE and A. C. JERMY*

For over a quarter of a century the genus *Selaginella* was studied by A. H. G. Alston (1902–1958), who produced a global survey of the genus by means of a series of regional taxonomic revisions. In most cases, these revisions are the most usable or even the only treatments available. Crabbe (1960, 1969) lists and indexes Alston's publications.

For the Americas, Alston's first treatment was for Brazil (1936), followed by Argentina, Uruguay, and Paraguay (1939), the West Indies (1952), and continental North America south to Panama (1955). At the time of his death, Alston had amassed data on some 120 species found in tropical South America excluding Brazil. The manuscript he left was incomplete and contained a number of new species. Repeated attempts to complete the work have been delayed as new problems presented themselves and the scope of the project escalated.

We have chosen to publish on this occasion seven species from the 26 that Alston recognized in his manuscript. The types of six of these species are at the Smithsonian Institution; the seventh is *Selaginella mortoniana*.

Although this paper is presented solely under our joint authorship, we wish to make it clear that it incorporates the concepts of Alston and that the initial recognition of the new species was entirely his.

Selaginella anaclasta Alston ex Crabbe & Jermy, sp. nov. Figs. 1 and 2

Caules prostrati flexuosi. Rami distinctissimi: primarii alterni, squarrosi; secundarii tertiique pinnati, breves, curvi ad apicem ramorum primariorum. Folia foliis *S. marginatae* (Humb. & Bonpl.) Spring similia, sed dentibus multicellularibus, cilium ad apicem instructis differunt.

Plant entirely prostrate. Stems glabrous, articulate, pale straw-colored, flexuose, at least 40 cm long, distantly and alternately pinnately branched; rhizophores dorsal in origin, descending, distant; lateral branch-systems 10–12 cm long, linear-oblong in outline, recurved or squarrose, bipinnately branched, the secondary branches often again branched, the ultimate branches curved towards apex. Leaves everywhere heteromorphic, shiny on both sides; lateral leaves 2.0 × 0.8 mm, spreading on the main stem and primary branches, regularly ca 2 mm apart but in the upper branches becoming imbricate, subcoriaceous, the apex acute, strongly dentate-ciliate on both margins, the teeth multicellular at the base and terminating in a cilium which is often broken off, the inner half-leaf[1] semi-oblong-lanceolate, gradually rounding to the base, the outer half-leaf semi-oblong, rotundate-truncate at the base; axillary leaves similar to the lateral leaves but somewhat smaller and more acute; median leaves 1.0 × 0.5 mm, imbricate, ovate-

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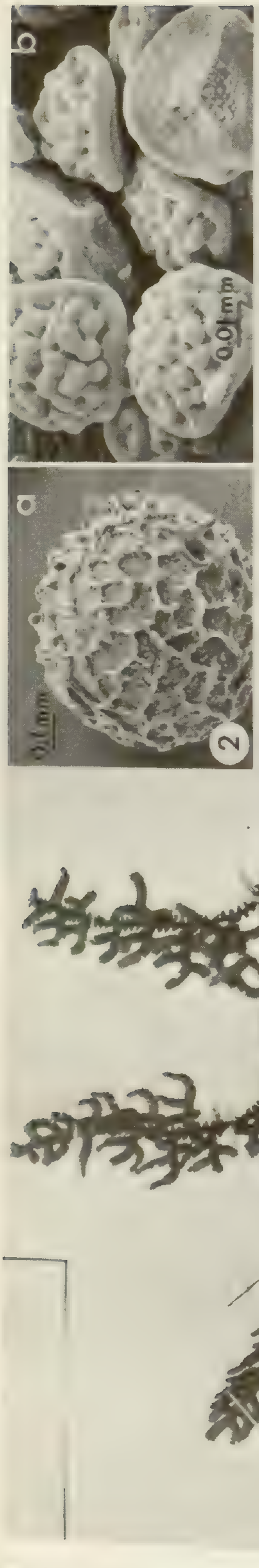
[1] We have used the term "half-leaf" for each of the two parts of the leaf blade divided by the midrib, the inner being on the acroscopic side, the outer on the basiscopic.



Figs. 1–2. Holotype of *Selaginella anaclasta*. Inset: dorsal side of secondary branch. Fig. 2a. Megaspore. Fig. 2b. Microspores. Fig. 3. Holotype of *Selaginella chionoloma*.

oblong, strongly denticulate-ciliate, biauriculate at the base with short, broad auricles, aristate at the apex, the arista entire or sometimes furcate. Strobili ca 3 × 2 mm, tetrastichous, single at the apex of tertiary branches, maturing ± simultaneously in each primary branch-system. Megasporophylls at the base of strobili, 2.0 × 1.3 mm, ovate, ciliate-dentate, the apex acute; megaspores (*Fig. 2a*) ca 500 μm in diam, pale yellow, the sporoderm covered with a white, sharply crested reticulum. Microsporophylls 1.5 × 0.8 mm, similar to the megasporophylls; microspores (*Fig. 2b*) ca 50 μm in diam, whitish-yellow, finely granular on the proximal face, verrucate on the distal face.

TYPE: Río Yatua, near Cumbre Camp, Cerro de la Neblina, Edo. Amazonas, Venezuela, 5 Jan 1954, *B. Maguire, J. J. Wurdack, & G. S. Bunting 37063* (US; photo and fragment BM). Locally frequent, festooning steep banks of runlet.

The leaf margin with multicellular teeth terminated by a long cilium makes this one of the most distinct species of the genus. Known so far only from the type.

Selaginella chionoloma Alston ex Crabbe & Jermy, sp. nov. Fig. 3

Species heterophylla ex affinitate *S. novae-hollandiae* (Swartz) Spring, sed foliis lateralibus eciliatis, planis, albo-marginatis, et foliis mediis angustioribus differt.

Stems glabrous, prostrate becoming erect, ca 12 cm tall, 0.7 mm in diam at the base and bearing several soboles; branch-system irregularly oblong in outline, with pinnate branches spaced up to 2.5 cm apart, up to 3.5 cm long; rhizophores restricted to the basal part; leaves everywhere heteromorphic. Lateral leaves 2.0 × 0.75 mm, spreading, widely spaced, narrowly oblong, acute, the inner half-face narrowly oblong-lanceolate, acutely dentate almost to the apex, with broad, white margins, the outer half-face narrowly oblong, almost entire; axillary leaves narrowly oblong-lanceolate, dentate, with broad, white margins, somewhat shorter than the lateral leaves; median leaves ovate-elliptic, distantly and acutely dentate, almost equilateral at the base, aristate at the apex, the arista equalling the lamina. Strobili terminal on the ultimate branches; sporophylls of two kinds similar to and contiguous with the lateral and median leaves; sporangia in both cases immature.

TYPE: Cuquipata, Valle de Lares, Depto. Cuzco, Peru, Feb 1928, *F. L. Herrera 1636* (US; isotype BM).

PARATYPES:

PERU: San Martín: Beyond Las Palmas near tunnel, Tingo María, ca 800 m, 30 Oct 1949–19 Feb 1950, *H. A. Allard 21130* (BM).

BOLIVIA: La Paz: Yanacachi, Yungas, June–July 1893, *P. Jay b* (NY).

No ecological notes are given, but it is suspected that this is a terrestrial species of banks in more open situations. The Jay specimens are very poor but seem to be this species, thus extending the range slightly.

It is with some hesitation that we describe this incomplete material as a new species, but the white-bordered leaves are very distinct and an easily determined character. Alston knew of no other species with such leaves and none have since come to our notice. We name the species here with the hope that eventually fully mature and sporing material will be found. The *S. novae-hollandiae* complex needs further investigation throughout its range, and more material showing the full extent of the branch-systems is particularly needed.

Selaginella hirsuta Alston ex Crabbe & Jermy, sp. nov. Fig. 4

Species heterophylla et habitu ex affinitate *S. hartwegianae* Spring, sed ab omnibus speciebus erectis foliis subtus hirsutis distinctissima.

Plant 25–30 cm high. Stems glabrous, erect from a short-creeping base, 1.5 mm in diameter at the base, the lower part unbranched, ca 12.5 cm high, straw-colored when dry, evenly covered with distant, similarly-shaped leaves; stem leaves ca 2.0 × 1.75 mm, ovate, subacute, cordate at the base, appressed, entire; rhizophores restricted to the base; frondose part broadly trullate, 15–20 × 12–15 cm, with the main branches 1–2-pinnate. Lateral leaves ca 3.0 × 1.5 mm, obliquely inserted ca 0.75 mm apart and becoming contiguous in tertiary branches, ovate, the upper surface glabrous, the lower surface with semi-appressed hairs, the midrib obscure, entire in upper half (but with the hairs often spread to give the impression of a ciliate margin) and often towards the base, the inner half-leaf semi-ovate, the outer half-leaf semi-oblong-elliptic; axillary leaves 1.5 × 1.0 mm, ovate-elliptic, subacute, similarly hairy beneath, entire; median leaves ca 1.5 × 0.75 mm, elliptic to broadly ovate, subacute, only slightly asymmetric at the base, glabrous on both sides, entire. Strobili 4–10 × 1 mm, single on the apices of the ultimate branches, maturing simultaneously. Mega- and microsporophylls similar, 10 × 6 mm, ovate-lanceolate, acute, dentate. Megaspores 205–220 μm, with a fine reticulum of low, smooth ridges, otherwise smooth; microspores 23–26 μm, verrucate, the verrucae echinulate.

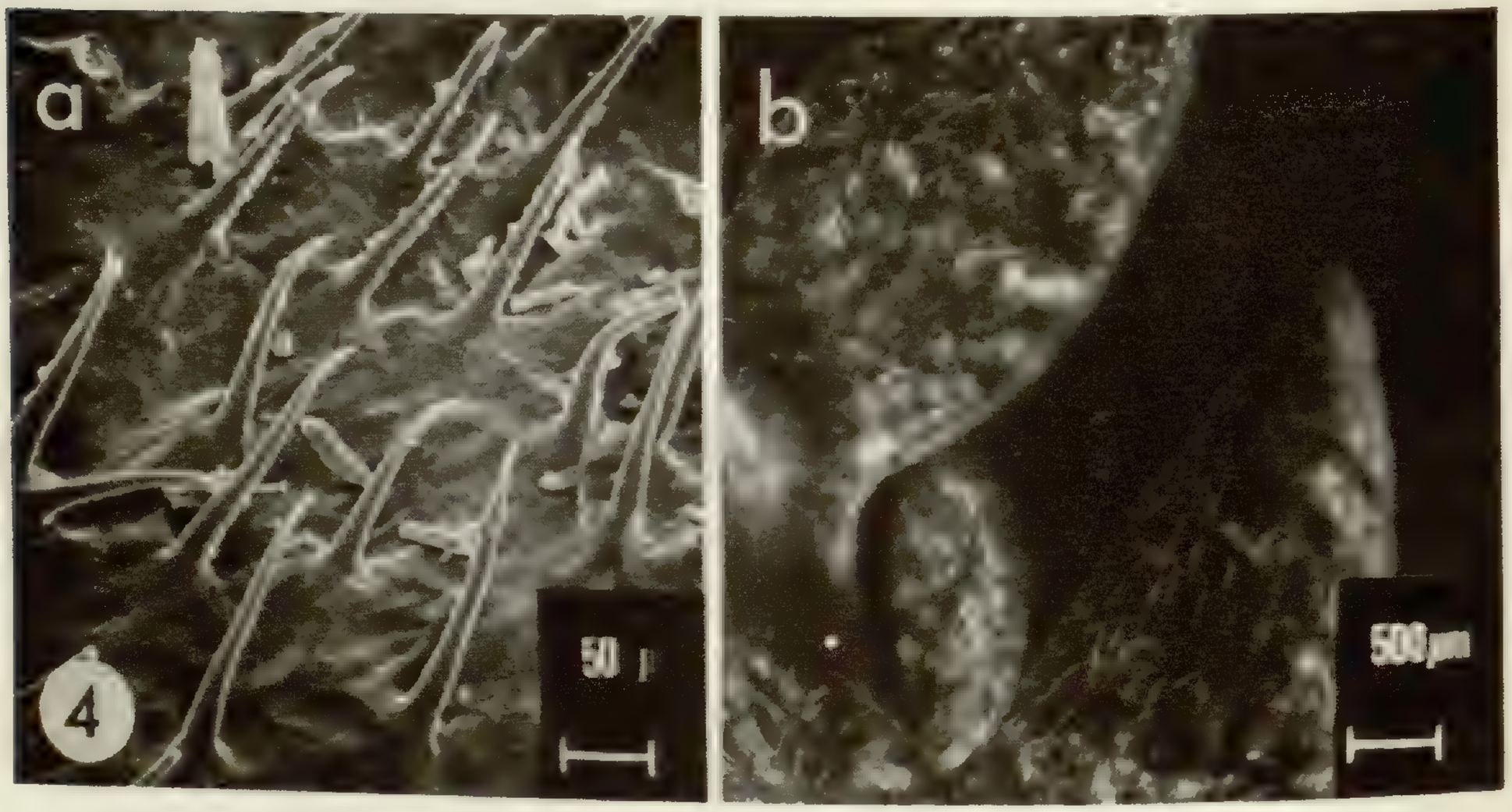


Fig. 4. Holotype of *Selaginella hirsuta*. Hairs on undersurface of lateral leaves.

TYPE: South-eastern portion of base of Carrao-tepuí, Edo. Bolívar, Venezuela, 1460–1615 m, 4–5 Dec 1944, *J. A. Steyermark 60844* (US; sterile isotype BM).

This species is known only from the type; no ecological data are known. This species is very similar to *S. hartwegiana*, but differs in having leaves with hairy undersurfaces. Selaginellas with hairy leaves are rare; in the American tropics we know only the creeping species *S. revoluta* Baker to have hairy leaves, and in this species the hairs are on the upper surface of the leaf.

Selaginella mortoniana Crabbe & Jermy, sp. nov. Fig. 5

Selaginella aciculata Alston *ms.*

Selaginella flabellata sensu Spring, Mém. Acad. Roy. Belg. **24:** 174. 1850, *pro parte quoad Linden 1004.*

Species heterophylla ex affinitate *S. flabellatae* (L.) Spring, sed foliis mediis longiaristatis (nec breviter acuminatis) et foliis lateralibus angustioribus basi cuneatis (nec truncatis) differt.

Plants glabrous, erect from a short-creeping base, ca 65 cm high. Stems 4 mm in diameter at the base; the lower part simple, 50 cm long, pale green-straw-colored when dry, covered throughout with homomorphic, subdistant leaves; stem leaves 6.0 ×1.75 mm, oblong-cuneate, acuminate, ciliate at the base; rhizophores restricted to the base. Frondose part broad-deltate in outline, the branches spaced 1.5–3.0 cm apart, 3–4-pinnate, lanceolate or ovate in outline, ca 15 × 5 cm. Lateral leaves ca 7 × 2 mm, obliquely inserted, contiguous or more distant in the lower part, narrowly ovate-deltate ± falcate, the upper surface dark green, paler beneath, the inner half-leaf semi-lanceolate, cordate, semi-amplexicaul and ciliate at the base, the outer half-leaf semi-elliptic-lanceolate, entire or with few hairs towards the base; axillary leaves oblong-cuneate, slightly oblique, ± cordate, ciliate in the lower half, entire above; median leaves 1.5 × 1.0 mm, asymmetric, entire, acuminate, long-aristate, the inner half-leaf narrowly deltate-ovate with a ± straight inner margin, the outer half-leaf semi-elliptic-oblong, auriculate and short-ciliate at the base. Strobili 20 × 2.25 mm, borne singly on the apices of the ultimate branches, tetrastichous. Mega- and microsporophylls similar, up to 2.0 × 1.2 mm, ovate, keeled, serrate, acuminate. Megaspores 315 μm in diam, pale ochre yellowish, the sporoderm finely granular, folded into a reticulum of low, smooth ridges. Microspores ca 24 μm in diam, pale yellowish, distantly papillate with fine granulations between the papillae.

TYPE: "In sylvis humidis," Mariquita, Depto. Tolima, Colombia, Dec 1842, *Linden 1004* (BM; isotypes BR, K).

PARATYPES:

COLOMBIA: Cundinamarca: Cordillera de Bogotá, *Triana s. n.* (BM). **Without precise locality:** *Linden 1002* (BM).

Linden 1004 was included by Spring (Monogr. Fam. Lycopod. 174–5. 1850) under *S. flabellata* (L.) Spring. Alston realized that this was a distinct taxon close to *S. anceps* (Presl) Presl, another species in the *S. flabellata* complex which needs further investigation. *Selaginella flabellata sensu stricto* has not hitherto been collected on the mainland of South America.

In 1938 Alston himself collected a large-leaved form in Venezuela (Parque Nacional, near El Portachuela, Edo. Aragua, *Williams & Alston 172*, BM). A similar specimen from Colonia Tovar (*Fendler 493*) was described by Alexander Braun as *S. flabellata* var. *latifrons* (Ann. Sci. Nat., Paris V, 3: 278. 1865). Alston had tentatively proposed to name this at specific rank as *S. mortoniana* (*S. latifrons* being pre-occupied for a Philippine species) in honor of Conrad Morton's interest in both the genus and South America. But we consider it to be not a species but a variant of *S. flabellata*, and comparable in every other respect with material from the Lesser Antilles. We are therefore naming this other species of the complex, segregated as new by Alston, in honor of Conrad Morton.

Fig. 5. Holotype of *Selaginella mortoniana*. Fig. 6. Holotype of *Selaginella palmiformis*. Left inset: microspore. Right inset: megaspore.

Selaginella palmiformis Alston ex Crabbe & Jermy, sp. nov. Fig. 6

Species heterophylla ex affinitate *S. mazaruniensis* Jenm., sed caulibus teretibus vel leviter quadrangularibus, et ramis primariis elongatis, breviter ramosis et pleris apice caulium aggregatis differt.

Plant 50–65 cm high; stems glabrous, erect from a short-creeping base, 2.5–4.0 mm in diam at the base, the lower part simple, 20–35 cm long, pale straw-colored when dry, entirely clothed with similar, barely contiguous leaves; rhizophores restricted to the base. Frondose portion of 3 or 4 primary branches subpalmately arranged, narrowly trullate or deltate in outline, 10–15 × 3–5 cm, pinnately branched, with the shorter, basal branches somewhat distal; secondary branches alternate, simple. Lateral leaves ca 6 × 2 mm, regularly imbricate, the upper surface darker green, regularly serrate throughout, the inner half-leaf semi-lanceolate, rotund at the base, the outer half-leaf semi-linear-oblong, truncate at base; axillary leaves ovate-deltate, serrate, slightly oblique; median leaves 2.0 × 0.5–0.75 mm, oblong-elliptic, shortly acuminate, sparsely toothed throughout. Strobili up to 60 × 1 mm, singly or occasionally in pairs on the tips of the branches, maturing ± simultaneously throughout the system, tetrastichous, sometimes branched. Mega- and microsporophylls similar, 1.75 × 0.75 mm, narrowly deltate, serrate, acute. Megaspores ca 525 μm in diameter, whitish-grey when dry, yellowish-grey when wet, the sporoderm with a reticulum of smooth, low ridges. Microspores ca 14 μm in diameter, pale yellowish, finely granular with prominent laesurae.

TYPE: Near Salto de Huá, western foothills of Sierra Imeri, Edo. Amazonas, Venezuela, 800 m, 27 Nov–8 Dec 1930, *E. G. Holt & E. R. Blake 490* (US; isotype BM).

PARATYPES:

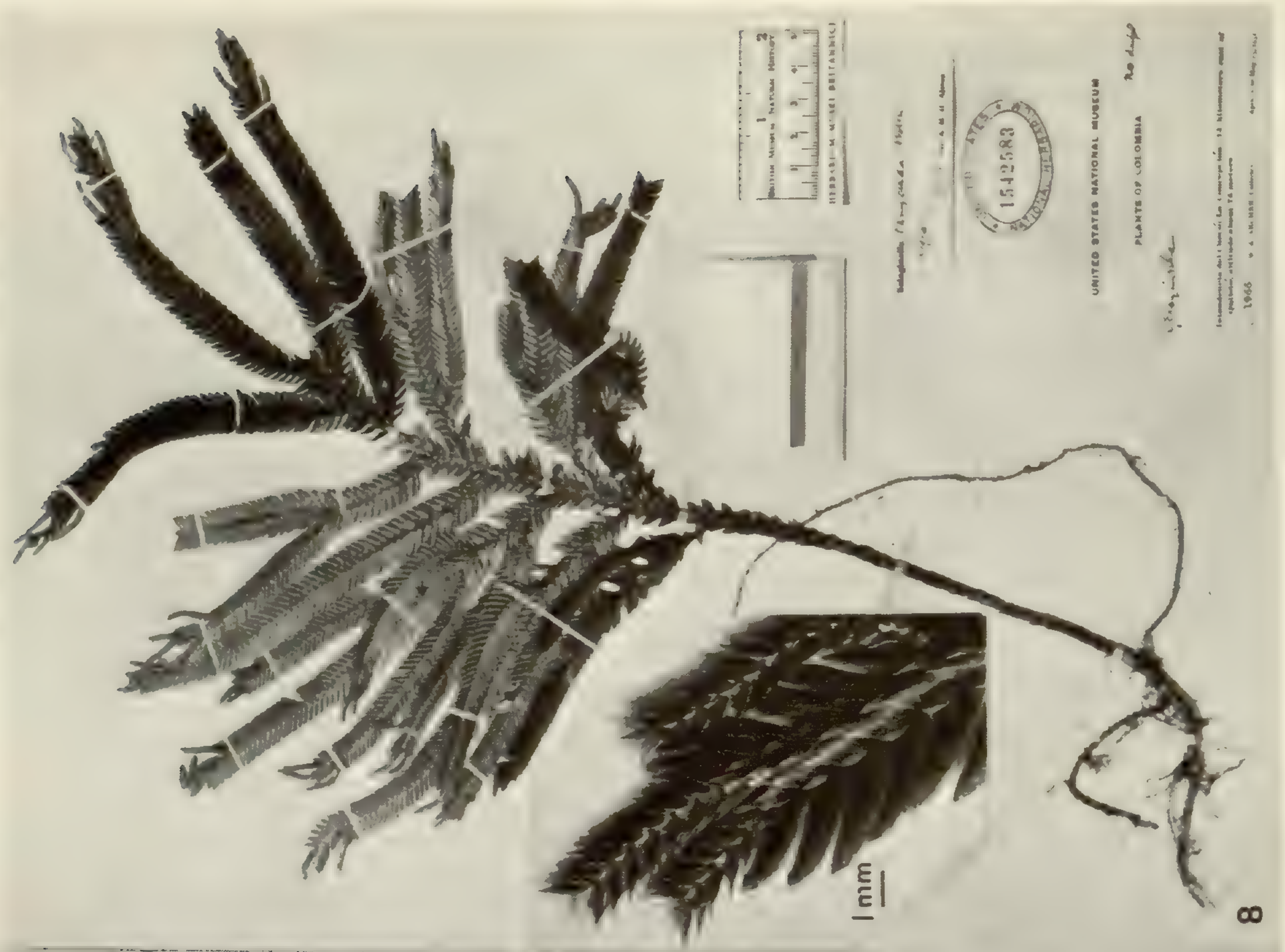
COLOMBIA: Amazonas: Río Miritiparaná, 212 m, 8 May 1952, *Schultes & Cabrera 16471* (US). **Vaupés:** Río Kananari, Cerro Isibukuri, 250–700 m, 28 Oct 1951, *Schultes & Cabrera 14465* (US); Vicinity of Cerro Monachí, Río Guainía, Río Naquieni, June 1948, *Schultes & López 10104* (BM); Caño Teemeeña, Río Piraparaná (tributary of the Río Apaporis), 5 Sept 1952, *Schultes & Cabrera 17190* (US), 10 Sept 1952, *17369* (US), *17396* (US); Caño Oo-gö'-dja, Jinogojé, Río Apaporis, 26 Aug 1952, *Schultes & Cabrera 17058* (US).

A plant of the forest floor; apparently confined to the sierras of the Amazonian part of Venezuela and Colombia.

Selaginella schultesii Alston ex Crabbe & Jermy, sp. nov. Fig. 7

Species heterophylla ex affinitate *S. ovifoliae* Baker, sed foliis intermediis distincte aristatis curvatis latioribus et longiciliatis, foliis lateralibus ovalis vice ovatis differt.

Stems glabrous, entirely creeping and for the most part intertwined, pale straw-colored, about 8 cm long, distantly alternately pinnately branched; lateral branches 1–2 cm long, simple or rarely irregularly branched; rhizophores borne in all branch axils; leaves heteromorphic throughout. Lateral leaves 1.25 × 0.8 mm, almost touching, ± symmetric, obtuse, often becoming mucronate, the inner half-leaf semi-ovate, ciliate at least to the middle, the outer half-leaf semi-oval, distantly ciliolate towards the base, but both margins with occasional long cilia throughout, the margins otherwise denticulate; axillary leaves ovate, oblique, ciliate; median leaves 0.8 × 0.5 mm, ovate-elliptic, distantly ciliate, the cilia on the outer margin somewhat larger, the apex aristate and falcate, often becoming recurved when dry, the arista ca 0.5 mm long. Strobili single at the apices of lateral branches,



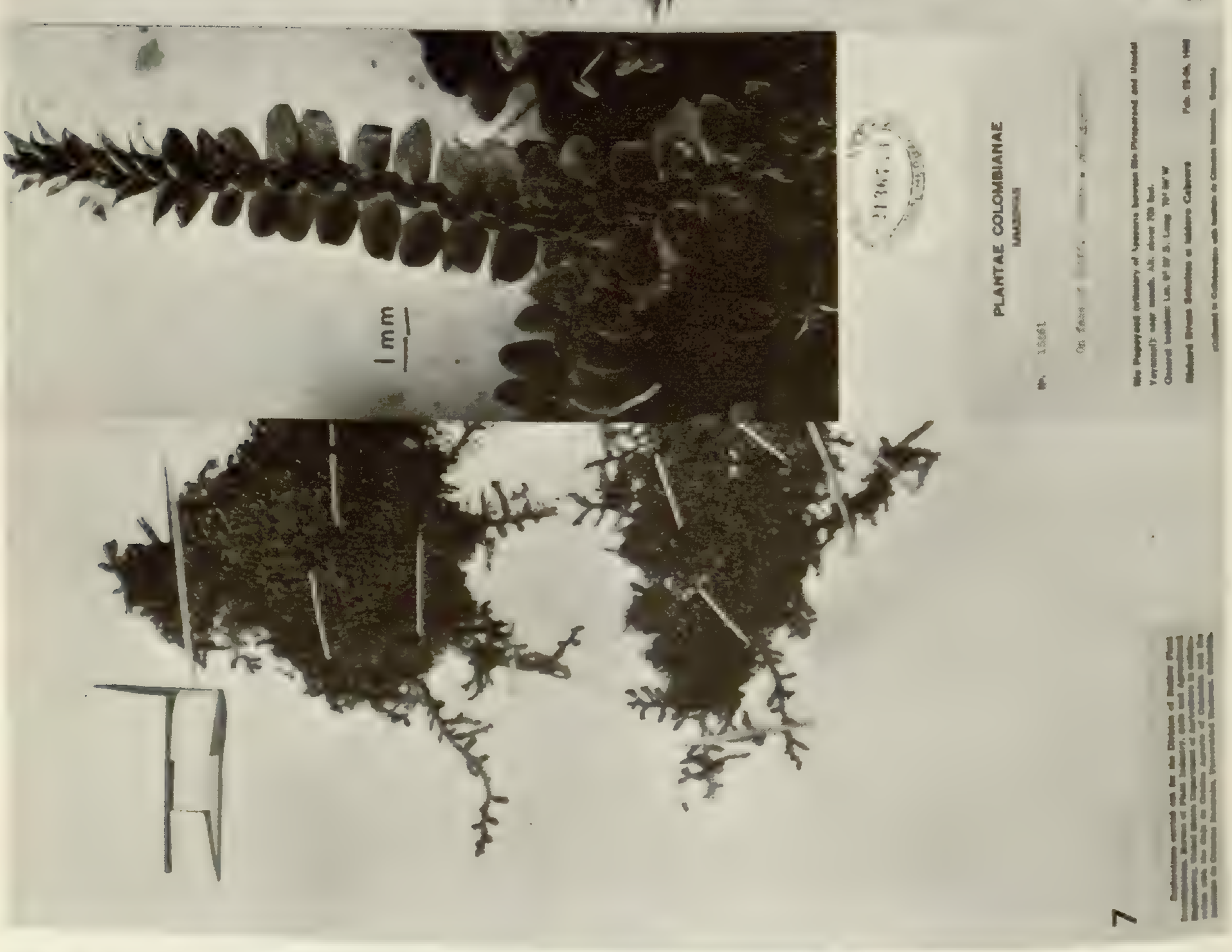


Fig. 7. Holotype of *Selaginella schultesii*. Inset: fertile branch. Fig. 8. Holotype of *Selaginella tanyclada*. Inset: tip of fertile branch.

tetrastichous, ca 3.0 × 0.5 mm. Mega- and microsporophylls similar, ovate, keeled, distantly ciliate, marginate, the apex acuminate and protracted into an arista. Megaspores ca 210 μm in diam, granulate, with a reticulum of smooth ridges. Microspores ca 30 μm in diam, pale yellow when wet, minutely scabrid.

TYPE: Between Río Piraparaná and Raudal Yayacopi, near the mouth of the Río Popeyacá (tributary of the Río Apaporis), Com. Amazonas, Colombia, 210 m, 22–26 Feb 1952, *R. E. Schultes & I. Cabrera 15561* (US; isotype BM).

PARATYPES:

COLOMBIA: Amazonas: Between Río Piraparaná and Raudal Yayacopi, near the mouth of the Río Popeyacá (tributary of the Río Apaporis), *Schultes & Cabrera 15575* (US); La Playa, Raudal Yayacopi, 800 ft, *Schultes & Cabrera 15417, 16205, 16898* (all US); Cachoiera de Jirijirimo and vicinity, Río Apaporis, ca 250 m, 13 June 1951, *Schultes & Cabrera 12456* (US). **Vaupés:** Cachoiera Mirití, Río Kananari, ca 250 m, *Schultes & Cabrera 14411* (US); Río Kananari, Cerro Isibukuri, 250–ca 700 m, 4 Aug 1951, *Schultes & Cabrera 13314* (US).

This species grows on wet, dripping cliffs, on peaty soil, and among mosses. *Selaginella homaliae* A. Braun is similar in habit, but has more oblong leaves which are more rounded at the apex and are almost eciliate. *Selaginella applanata* A. Braun also has more elongate, oblong lateral leaves.

Selaginella tanyclada Alston ex Crabbe & Jermy, sp. nov. Fig. 8

Species heterophylla ex affinitate *S. bombycinae* Spring, sed foliis mediis sensim acuminatis et aristis brevioribus, foliis lateralibus apicem versus angustatioribus differt.

Plant up to 35 cm tall. Stems glabrous, erect from a short-creeping base, 3.5 cm in diameter at the base, with creeping soboles below; lower part simple, ca 15 cm long, pale straw-colored when dry, thickly covered with homomorphic leaves almost to the apex; rhizophores restricted to the base; stem leaves 4 × 4 mm, often also on the lowest parts of the primary branches, ovate-deltate, acute, frequently oblique at the base, minutely denticulate with occasional cilia especially on the slightly auriculate base. Frondose part ovate-orbicular in outline, with primary branches up to 2 cm distant, simple or 1-furcate, up to 15 cm long; lateral leaves 10 × 4 mm, contiguous or somewhat overlapping, elongate-deltate, the inner half-leaf linear to semi-lanceolate, rounded and expanded at the base, ciliate at the base, elsewhere ± entire or minutely denticulate, the outer half-leaf semi-oblong, truncate at the base and with some hairs, cuneate at the apex, entire; axillary leaves lanceolate-deltate, ciliate at the base, acute at the apex; median leaves 4 × 2 mm, obliquely ovate, erect and forming a very regular ridge in center of the branch, ciliate at the base, cordate on the outer side, acute or acuminate and shortly aristate. Strobili 15 × 2 mm, singly or paired at the apices of branches, or on short terminal branchlets of the primary branches, tetrastichous. Mega- and microsporophylls similar, 1.9–2.2 × 1.0 mm, oblong-deltate, keeled, serrulate, acuminate-subulate. Megaspores ca 450 μm in diam, all those seen not fully mature, granular becoming verrucate on the proximal faces and with an incipient reticulum of smooth ridges on the distal face. Microspores ca 20 μm in diam, with open-spaced papillae, the whole surface echinulate.

TYPE: La Concepción, 15 km E of Quibdó, Depto. Chocó, Colombia, ca 75 m, 20 Apr–23 May 1931, *W. A. Archer 1966* (US; fragment BM).

PARATYPE: Alto del Buey, Serranía de Baudó, Depto. Chocó, Colombia, 1000 m, 9 June 1940, *von Sneidern s. n.* (S-PA; photo BM).

This species, which grows in forests, is very close in habit and stature to *S. bombycina* Spring that is found in Ecuador and Peru; it may well represent a northern extension of that complex. The median leaves of *S. bombycina* are very asymmetrical; they are almost semicircular in the outer half and are more abruptly tapered into a distinct, subulate arista.

LITERATURE CITED

ALSTON, A. H. G. 1936. The Brazilian species of Selaginella. Repert. Sp. Nov. Fedde **40:** 303–319.

———. 1939. The Selaginellae of Argentina, Uruguay and Paraguay. Physis, Buenos Aires **15:** 251–257.

———. 1952. A revision of the West Indian species of Selaginella. Bull. Brit. Mus. (Nat. Hist.) Bot. **1:** 25–47.

———. 1955. The heterophyllous Selaginellae of continental North America. Bull. Brit. Mus. (Nat. Hist) Bot **1:** 219–274.

CRABBE, J. A. 1960. A. H. G Alston (1902–1958): a bibliography of his writings, with a short introduction and a list of new taxa and nomenclatural changes published by him. J. Soc. Bibliogr. Nat. Hist. **3:** 383–404.

———. 1969. A. H. G. Alston, 1902–1958: additions and an index to his publications. J. Soc. Bibliogr. Nat. Hist. **5:** 240–248.

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AMERICAN FERN JOURNAL

Volume 63

Number 4

October–December, 1973

QUARTERLY JOURNAL OF THE AMERICAN FERN SOCIETY

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Natural Origin of the Appendageless Psilotum[1]

ALBERT S. ROUFFA*

On a visit to Japan in the fall of 1972 I learned that the appendageless-Psilotum cultivar brought to this country by Dr. John Creech in 1957, and reported upon by me (Amer. Fern J. **61:** 75–86. 1971), had been mislabeled sometime before I received it in 1967. The actual name by which it is known in Japan is *Bunryu-zan*, or simply "Mt. Bunryu." This would hardly be startling news, except perhaps for

Illustrations from 18th century Japanese Psilotum books. Fig. 1. Cultivar '*Bunryu-zan*,' from "Matsuran-fu," vol. 1. (1837). Fig. 2. Cultivar '*Yoji-Bunryu-zan*' (Poplar-twig Bunryu-zan) from the same book. A variety with some crowding of axes at the tips, not noticeable in this rendering, which may be only a cultural effect.

the fact that it is a geographical name—something that is quite unusual in Japanese Psilotum cultivars. Immediate questioning of my Japanese hosts drew no answer to the actual location of such a mountain, but they did insist that it was the place where the variety had been first collected. Later, during a visit to the National Library in Tokyo, I saw illustrations of the cultivar *Bunryu-zan*—appendageless and bearing terminal sporangia (*Figs. 1–4*)—in two books published in 1835 and 1837, 16–18 years before Commodore Perry arrived in Japan. In Volume 1 of the 1837 book (*"Matsuran-fu"* or "Psilotum-illustrated") a caption states that the

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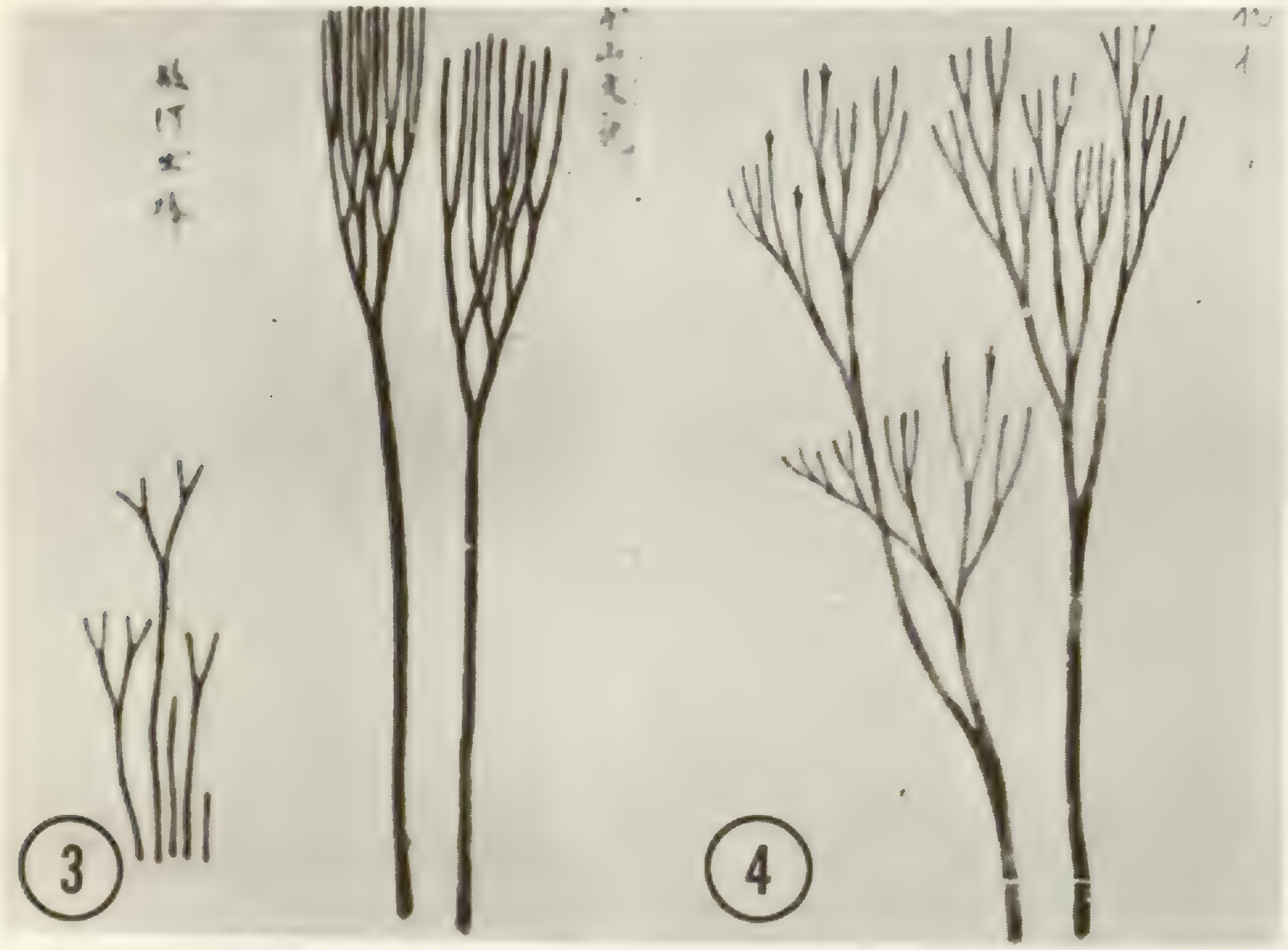
[1]Supported by a grant (12972) from the National Geographic Society.

Volume 63, number 3, of the Journal, was issued November 15, 1973.

variety was collected at Mt. Bunryu in Kishū. The latter is an old name for a province that included what is now known as Wakayama Prefecture in the region of the Kii mountains. A visit to this area revealed that there is a double-peaked mountain some ten miles east of the city of Tanabe called *Bunryo-zan* ("Mt. Bunryo" or "Divided-mountain"), which has been well known by the inhabitants of the region as a good plant collecting locale. Suffice it to say, the slight difference in the sound of the name is probably a matter of a liberty that was taken in converting verbal Japanese into the Chinese style calligraphy (Kanji), in keeping with the notions of elegance of the late Edo period. So it appears that there is a reasonable evidence that the appendageless-cultivar was collected from a wild population, and well before 1835.



Illustrations from 18th century Japanese Psilotum books. Fig. 3. Cultivar '*Moto-yama Bunryu-zan*' (Original-mountain Bunryu-zan) from "*Toto-Matsubaran-fu*" (1835), the oldest book of its type still in existence. Fig. 4. Cultivar '*Yoji-Bunryu*,' from the same book. Crowding of axes is shown on some shoot tips.

I am not positive, but there is some indirect evidence which I must still verify, that more than one collection of "appendageless" Psilotums was made, and possibly in more than one location. If this is so, then it is of more than passing interest. I stated in 1971, before I knew of the natural origin of this variety from Mt. Bunryo two centuries ago, that "there is a remote chance that it represents one of the last of a nearly extinct race of *Psilotum*." The question posed is still valid today.

A Simple Method of Initiating Axenic Cultures of Pteridophytes from Spores[1]

D. V. BASILE*

Axenic cultures—those which contain only a single species—of pteridophyte gametophytes are useful both for research and teaching related to genetics, physiology, morphology and systematics (cf. Mickel, 1971). For several reasons, pure cultures of these plants are preferable to mixed cultures obtained from natural habitats or from unsterilized spores. For the researcher, axenic cultures eliminate the unknown influences that would be introduced by contaminants and permit a greater degree of control over experimental variables. For the teacher and student, pure cultures of plants under controlled conditions increase the probability that specific plants will be available for study during the time, in the quantity, and at the stages of development desired. Indeed, the gametophytes of many pteridophytes are difficult if not impossible to obtain from the field at any time, especially for instructors working in large, metropolitan areas. Many of us have been forced to learn and teach about this important and interesting phase of pteridophyte life history from the limited material commercially available and from textbook descriptions.

One factor that may limit the wider use of axenic gametophyte cultures is the need for transfer rooms or chambers in which to surface-sterilize spores and inoculate cultures. Even though small, relatively inexpensive, bench-top transfer hoods are available (e.g., "Labconco" tissue culture hoods), a sufficient number of these to accommodate all the students in a laboratory course may be difficult to provide. Over the years I have attempted to develop culture techniques which keep space and cost requirements to a minimum, thus enabling my students and me to culture a variety of plants and plant parts. This note presents a modification of some previously reported culture techniques (Basile, 1964, 1972) and their adaptation to the culture of pteridophyte spores. The resultant modification completely eliminates the need for transfer rooms or chambers and makes pteridophyte spore culture feasible even with modest facilities.

MATERIALS

Alcohol lamp
"Alconox" detergent (product of Alconox, Inc., NY)
Autoclave or pressure cooker
"Clorox" (commercial preparation of 5.25% sodium hypochlorite)
Cotton, non-absorbent, plugging
Distilled or deionized water
Ethanol, 70% and 95%
Filter paper discs, 13 mm, Whatman #2

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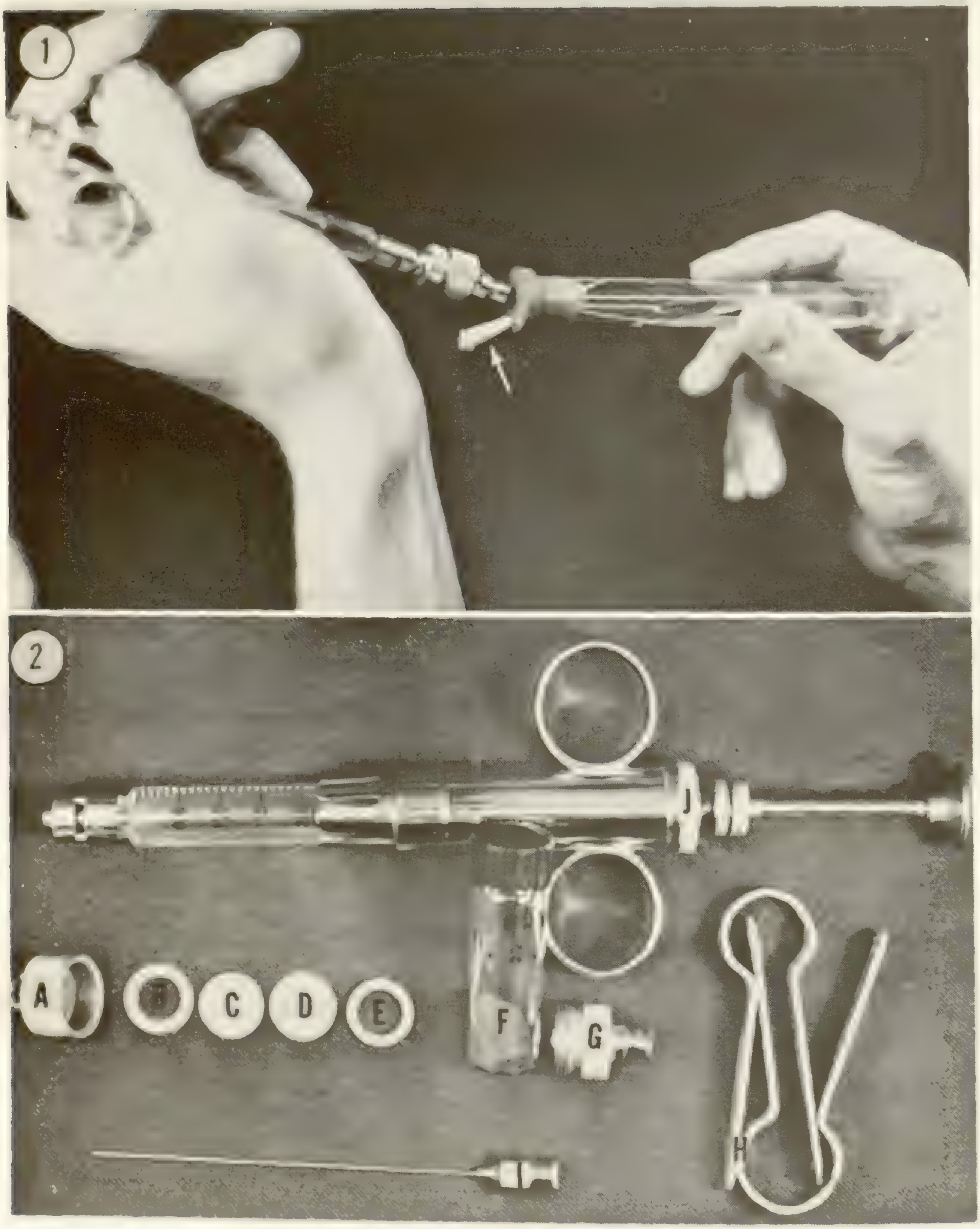
[1]Thanks are due to Prof. Warren H. Wagner, Jr., for his useful suggestions for improving the manuscript.



Figs. 1 and 2. Special facilities used for "washing machine" technique. Fig. 1. Test tube adapted to contain sterilizing solution or sterile, distilled, rinse water. Note the orientation of the vent needle (arrow). Fig. 2. Components of the "washing machine." The lower portion of the filter housing (A), the flat "Teflon" gasket (B), the metal support grid (C), the "Miracloth" or filter paper disc (D), and the Teflon O-ring (E) are assembled before the spores (F) are deposited on the "Miracloth" disc. The upper part of the housing (G) is screwed on and the assembly tightened with wrenches (H). The needle (I) and pipetting syringe (J) are affixed to (A) and (G), respectively.

Hypodermic needles, 3″, 20-gauge, steel hub; and 1½″, 18-gauge, disposable
"Miracloth" discs, 13 mm (A bonded cloth of rayon and cellulose; product of Visking Corp., Chicago, IL)
Pipetting syringe, Becton Dickenson Cornwall, 2 cc capacity (Becton, Dickenson and Co., Rutherford, NJ)
Serum bottles, Wheaton type
Serum bottle stoppers, Wheaton type
Squeeze bottle, plastic
"Swinny" syringe adapter for Millipore Filters (Millipore Corp., Bedford, MA)
Test tubes, 15 × 150 mm
Test tube rack

PROCEDURE

Although the procedure to be described is performed as a more or less continuous process, it comprises three logically separable operations: (a) surface-sterilizing the spores, (b) preparing a spore suspension, and (c) inoculating aliquots of the spore suspension into culture vessels.

In an effort to be as concise as possible, the method is presented as a set of directions. It should be understood that alternatives to the steps as given, or the materials used, are possible.

1. Prepare in advance test tubes of sterile, distilled water to be used to rinse spores. Four tubes are needed for each batch of spores being surface-sterilized.

Put about 10 ml of distilled water in each test tube. Stopper the tubes with Wheaton type serum bottle stoppers, which are pierced by an 18-ga hypodermic needle plugged with cotton *(Fig. 1)*. This needle functions as a vent.

Autoclave the water for 15–20 min at 15 psi and 121°C. Allow it to come to room temperature before use.

2. Prepare spores for surface-sterilization according to the method of Voeller (1964); that is, separate the spores from sporangia and other debris by sifting them through 200-mesh screening onto waxed (or similarly smooth-surfaced) paper. Transfer the spores to screw-capped vials.

The spores should be stored at 5°C until used.

3. Prepare a fresh solution of 7% (v/v) "Clorox" and ca 0.1% (w/v) "Alconox" in distilled water.

Pour about 10 ml of this solution into a clean test tube and stopper it in the same way as the distilled water rinse tubes (step 1 and *Fig. 1*).

Use a fresh 10 ml aliquot of the solution for each batch of spores to be surface-sterilized.

4. Load the spores into a partially assembled filter housing ("Swinny" adapter) and complete the assembly as indicated in *Fig. 2*.

Use "Miracloth" discs unless the spores are so small (20μ or less in diam) that they pass through, in which case use Whatman #2 filter paper discs.

5. Affix a 3″, 20-ga, metal-hubbed hypodermic needle and a 2 cc Cornwall pipetting syringe to the loaded filter housing. Set the plunger to deliver 1 cc. This total assemblage is called a "washing machine" *(Fig. 2)*.

6. Wet the surfaces of the serum bottle stoppers of four tubes containing sterile water and the tube containing the sterilizing solution with 70% ethanol.

7. Pass the needle of the "washing machine" over the alcohol-flooded surface of the tube containing the sterilizing solution. Flame the needle and insert it through the stopper.

8. Tilt the tube to an almost horizontal position and in such a way that the tip of the vent needle is up out of the solution and the tip of the "washing machine" needle is down in the solution *(Fig. 1)*.

9. Pump the "Clorox"–"Alconox" solution back and forth through the housing for 1 min. More or less time may be necessary for sterilization; this can only be determined empirically.

Turn the test tube upright, expel the solution from the system (some will remain), and allow the syringe plunger to come up while the tip of the needle is still in the tube but not in the solution.

10. Withdraw the needle, pass it over the alcohol-wet surface of the first rinse tube's stopper, flame the needle, and insert it through the stopper.

11. Tilt the tube to an almost horizontal position so that the tip of the vent needle is up out of the water and the tip of the "washing machine" needle is in the water *(Fig. 1)*.

12. Pump the sterilized water back and forth 10 pumps, turn the tube upright, expel the rinse water, and allow the syringe plunger to come back up while the tip of the needle is still in the tube, but not in the water.

13. Repeat steps 10–12 two more times.

14. Use the sterile water in the fourth tube to prepare the spore suspension. Proceed as in steps 10–12 *except* do not turn the tube upright on the last pump. Rather, allow the plunger to come back slowly so that water carries the spores into the barrel of the syringe and as little air as possible enters. Turn the adjustment screw so that the 2 cc calibrated portion of the barrel fills with spore suspension.

15. Leave the needle inserted through the stopper. Remove the syringe from the filter housing and the filter housing from the needle. Flame the Luer-Lok of the syringe and the hub of the needle, and affix the syringe directly to the needle.

The syringe filled with the spore suspension can now be used to inject aliquots into any culture vessel that can be closed with a serum bottle type stopper (Basile, 1964).

16. Wet with 70% alcohol the stopper surfaces of the vessels to be inoculated.

17. Pass the needle of the syringe over the alcohol-flooded surface of the stopper, flame the needle, and insert it through the stopper. Agitate the syringe to suspend the spores more uniformly, and turn the adjustment screw of the metal syringe housing to deliver a portion of the spore suspension.

18. Repeat step 17 for each additional culture vessel to be inoculated.

DISCUSSION

The advantage of this simple, sterile technique is that it facilitates initiating single-species cultures of any pteridophyte from which viable spores are obtainable. Conditions for maintaining such cultures are, likewise, not difficult to satisfy. The composition of the culture medium and conditions of incubation will, of

course, depend on the pteridophyte and the purpose for culturing it. In this regard the reader might consult, in addition to those cited above, the papers by DeMaggio (1961), Freeberg and Wetmore (1957), Hauke (1969), Kato (1963), and Steeves et al. (1955), which provide a core of information concerning suitable culture conditions for a variety of pteridophytes as well as further examples of their great potential for teaching and research.

LITERATURE CITED

BASILE, D. V. 1964. New procedures of bryophyte cultures which permit alteration of the culture medium during the life cycle. Bryologist **67:** 141–146.

————————. 1972. A method for surface-sterilizing small plant parts. Bull. Torrey Bot. Club **99:** 313–316.

DeMAGGIO, A. E. 1961. Morphogenetic studies on the fern Todea barbara (L.) Moore. I. Life history. Phytomorphology **11:** 46–64.

FREEBERG, J. A. and R. H. WETMORE. 1957. Gametophytes of Lycopodium as grown in vitro. Phytomorphology **7:** 204–217.

HAUKE, R. L. 1969. Gametophyte development in Latin American horsetails. Bull. Torrey Bot. Club **96:** 568–577.

KATO, Y. 1963. Physiological and morphogenetic studies of fern gametophytes by aseptic culture I. Bot. Gaz. **124:** 413–416.

MICKEL, J. (Ed.) 1971. Ferns as tools in solving biological problems (AIBS Symposium). Bioscience **21:** 225–227, 266–275, 313–324.

STEEVES, T. A., I. M. SUSSEX, and C. R. PARTENEN. 1955. In vitro studies on abnormal growth of prothalli of the bracken fern. Amer. J. Bot. **42:** 232–245.

VOELLER, B. R. 1964. Antheridogens in ferns. *In* Régulateurs naturels de la Croissance Végétale. Colloq. Intern. Centre Nat. Rech. Sci. No. 123 Paris, pp. 665–684.

Notes on Three Ferns from Baja California, Mexico

IRA L. WIGGINS*

Several species of small ferns native in Baja California, Mexico, are poorly known to many students of fern taxonomy. Some of them are difficult to identify without access to extensive collections and to a wide range of bibliographic resources. Collections of three such species had been examined, laid aside, re-examined, and again put aside until they were submitted some time ago to Conrad V. Morton, who reported that they were *Cheilanthes viscida* Davenp., *Cheilanthes peninsularis* Maxon, and *Notholaena peninsularis* Maxon & Weatherby.

In order to make some of the characteristics of these attractive little ferns more readily apparent to others who may not have an opportunity to acquire or examine specimens from the peninsula, drawings of certain features of each of the above species have been prepared and are presented here. A few additional notes of explanation will, I hope, make the salient characteristics of these three ferns apparent.

Cheilanthes viscida Davenp., Bull. Torrey Bot. Club 6: 191. 1877. Fig. 1
TYPE: "White Water Canyon, in the Colorado Desert," *J. G. Lemmon.* (No date or number of the collection provided).

The tips of the ultimate segment lobes of the fronds are strongly recurved and slightly cucullate (*Fig. 1C*). These downwardly curled tips completely obscure the young sporangia and hide all save the marginal mature ones, and take the place of indusia as protective covers of the soral masses.

The blades of the fronds are devoid of scales, except for a few along the rachillae on the under side. Similar pale brown to cinnamon-colored, small scales sparsely invest the lower third of the stipe. These scales are crinkled, irregularly twisted, marginally crispate, and sometimes forked. They lack any thickening or darkening of the mid-stripe, being concolorous completely across their width (*Figs. 1E–H*). The outer walls of the marginal cells of each scale are, however, only about one-half as thick as the inner walls of the same cells and of the inter-cellular walls of all cells interior to the marginal ones (*Fig. 1N*).

Globose oil glands, which vary from sessile to short-stalked, occur on both surfaces of the blades. Those on the upper surface tend to have only one or two stalk-cells, or none at all, whereas those on the lower surface range from sessile to stalked with 2 to 4 or occasionally 5 stalk cells (*Fig. 1I*, in which the upper surface is at the left of the figure). This figure also shows the abruptly downward turned tip of a segment. *Figures 1J–M* indicate the variation in length of stalks. The terminal glands rupture and spread a layer of viscid material over the frond.

Mature spores are approximately 65 μm in diameter, dark brown, and distinctly reticulate with thin, more or less sinuous walls separating the reticulations (*Fig.*

*Dudley Herbarium, Stanford University, Stanford, CA 94305.

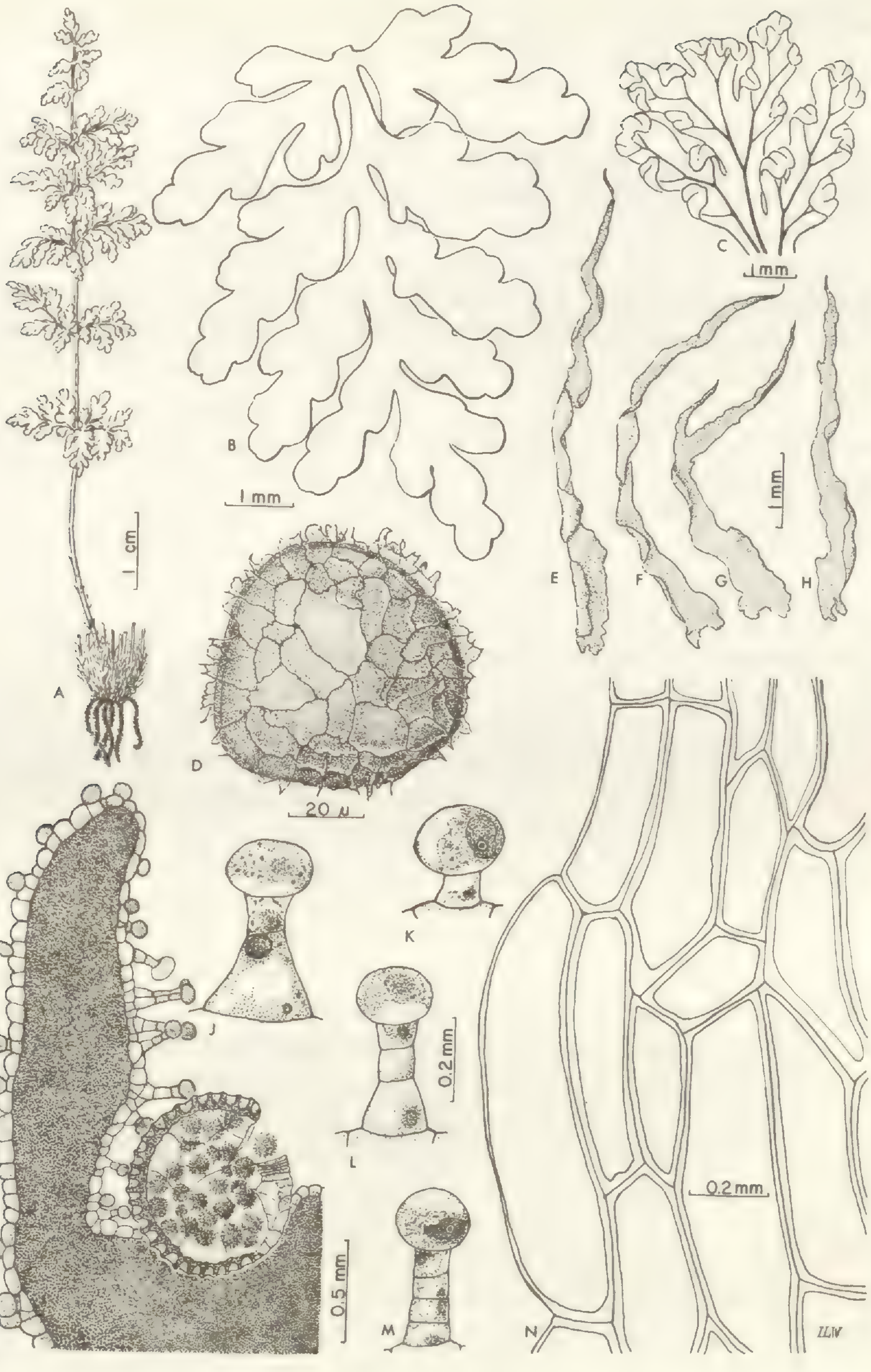


Fig. 1. *Cheilanthes viscida*. A, Frond and bases of stipes attached to erect rhizome. B, Inferior basal pinnule of basal pinna. C, Apical part of fruiting pinna, from underneath, showing incurved tips of segments and the venation. D, Spore, from outer, convex surface. E–H, Scales from basal part of stipe. I, Vertical transection of part of a pinnule segment showing relationship of stalked and sessile glands on epidermis. J–M, representative stalked glands from rachis and rachillae. N, arrangement of cells in concolorous scale from base of stipe.

ID). The spores borne by my specimens were remarkably uniform in size and showed almost no abortion.

The fronds of this fern become tightly incurled, brittle, and dark brown soon after the onset of dry weather. The usual habitat is in crevices of rocky canyon walls or cliffs, at the bases of north-facing boulders on brushy hillsides, and occasionally in gravelly soil beneath dense shrubs. It rarely is present in abundance at any station, and considerable distance often separates colonies. This fern ranges from Inyo County, California, to the western margins of the Colorado Desert, and south into the Sierra Juarez in Baja California, where it has been collected at an altitude of 2500 feet above sea level along the Cantu Grade. It is known to occur at altitudes of from 600 feet to about 5200 feet, the higher recorded localities being in Surprise Canyon, Panamint Mountains, Inyo County, California.

The species is represented by 14 sheets in the Dudley Herbarium, and by a half dozen sheets in the herbarium of the California Academy of Sciences.

One of the most distinctive features of this fern is the profusion of oil glands on the fronds and the stickiness of such fronds when handled or placed in pressing papers. The exudate from the glands tends to stain papers brown during pressing, and sometimes also the herbarium sheets.

Cheilanthes peninsularis Maxon, Contr. U. S. Nat. Herb. 10: 496. 1908. Fig. 2

TYPE: "Cape Region of Lower California, Mexico," Nov 1902, *T. S. Brandegee* (US).

Unlike the segments in *C. viscida*, the margins and tips of pinnules are virtually flat and are not curved under, thus leaving the sporangial masses totally unprotected. The venation in the pinnules of this species displays more intricate branching than does that of *C. viscida*, thereby furnishing the leaf blade with a close system of vascular strands (*Fig. 2B*). Scales ranging from less than 1 mm to over 5 mm in length are borne in fairly large numbers on the rachis and rachillae of the blades. They are shown in detail only to indicate something of their diversity (*Figs. 2C–E*, and *G*). Intermingled with the scales are scattered, gland-tipped hairs consisting of a single row of elongate cells, with the terminal gland made up of one to three vescicles (*Figs. 2F, H*). There are no sessile or stipitate glands on the surface of the leaf blades, the few present on the plants being confined to the rachises and subsidiary veins. However, most of the slender scales bear glands at their tips (*Figs. 2C–E, G*). The stipes are devoid of both hairs and scales.

The rhizome scales are similar to those on the leaves, but are slightly longer than those of the rachillae and further differ in having a distinctly sclerified central strip of very dark to almost black-walled cells (*Figs. 2I–L*). *Figure 2M*, which is a portion of such a scale, indicates the relative amount so thickened and darkened; one of the several-branched, shorter scales that occur at random on the rhizome (*Fig. 2N*) further exhibits the variations among the scales.

The spores of *C. peninsularis* are considerably smaller than those of *C. viscida* and are merely rugulose in a reticulate pattern, with the ridges much lower, smoothly rounded, and less conspicuous than the thin, lacerate walls marking the reticulations on spores of *C. viscida* (*Figs. 2O, P*).

Fig. 2. *Cheilanthes peninsularis*. A, single frond. B, Terminal part of pinna showing venation. C–E, G, Scales from rachis. F, H, Gland-tipped hairs from rachis. I–L, Representative scales from rhizome. M, Cell pattern from section of rhizome scale as indicated by cross lines in I. N, Branched scale from rhizome. O, P, Outer, convex surface and inner, commissural faces of spores, respectively.

This fern occurs at the bases of well shaded, often damp to dripping canyon walls, and grows out of rock crevices, but almost never in soil or gravel below the steep to vertical cliffs. It ranges from near sea level to nearly 2000 feet elevation and is known only in Baja California, from near Comondú and canyons leading into the mountains from Bahîa de la Concepción, southward to the Cape Region.

Notholaena peninsularis Maxon & Weath., Contr. Gray Herb. 127: 15. 1939.

Fig. 3.

TYPE: "Sierra de la Laguna, from San Bernardo to El Sanz," 3500 ft alt, 21 Jan 1906, *Nelson & Goldman 7430* (US).

The original Latin description is fairly full and is accompanied by a brief comparison between it and *N. nivea* and another species of the complex, *N. incana*.

Venation of the pinnules is similar to that in *C. peninsularis*, the veinlets forking 2–4 times, or occasionally only once. Tips of the segment lobes are not curled under, but are delicately crenulate (*Figs. 3A, B*). No scales occur on the blades nor rachillae, and those on the rhizome are thin, moderately contorted, non-thickened centrally, and have uneven margins (*Figs. 3C–E*).

The outstanding characteristic of *N. peninsularis* is the presence of white, globose or broadly obovoid, sessile wax glands borne singly or in groups of 2 to 5 on the under surface of the lamina (upper right part of *Fig. 3F*, detail in *Fig. 3H*). These wax glands are inconspicuous at first, but soon rupture and the wax coalesces into plaques that often are roughly stellate in outline, or may entirely cover considerable areas with a milk-white substance. Intermingled with the wax glands, but soon enveloped by the wax, are golden oil-glands set on stubby, rather thick stalks. Usually these stalks are a single cell wide (*Figs. 3F*, part of *G, I*), but occasionally the basal tier is of two or three cells (gland at left of *Fig. 3G*).

The stalks of the sporangia also are quite short and broad (*Fig. 3F*, upper part).

The spores of *Notholaena peninsularis* are only 35 to 45 μm in diameter and are relatively smooth (*Figs. 3J, K*), a feature remarked on by the authors.

This fern grows in soil on shaded slopes, in crevices of granitic boulders and under overhanging margins of boulders, and in shaded niches on talus slopes. Often it occupies spots on seepy hillsides and along rills at altitudes of about 1500 to 5000 feet altitude, in the mountains of the Cape Region. Before being separated by Maxon and Weatherby, the species was usually identified as *N. nivea, N. candida,* or *N. incana*.

None of these ferns is conspicuous. They usually are less than 2 dm in height, often tucked back under an overhang, in deep shadow, and easily by-passed. But each is attractive enough to make a search for it well worth the effort.

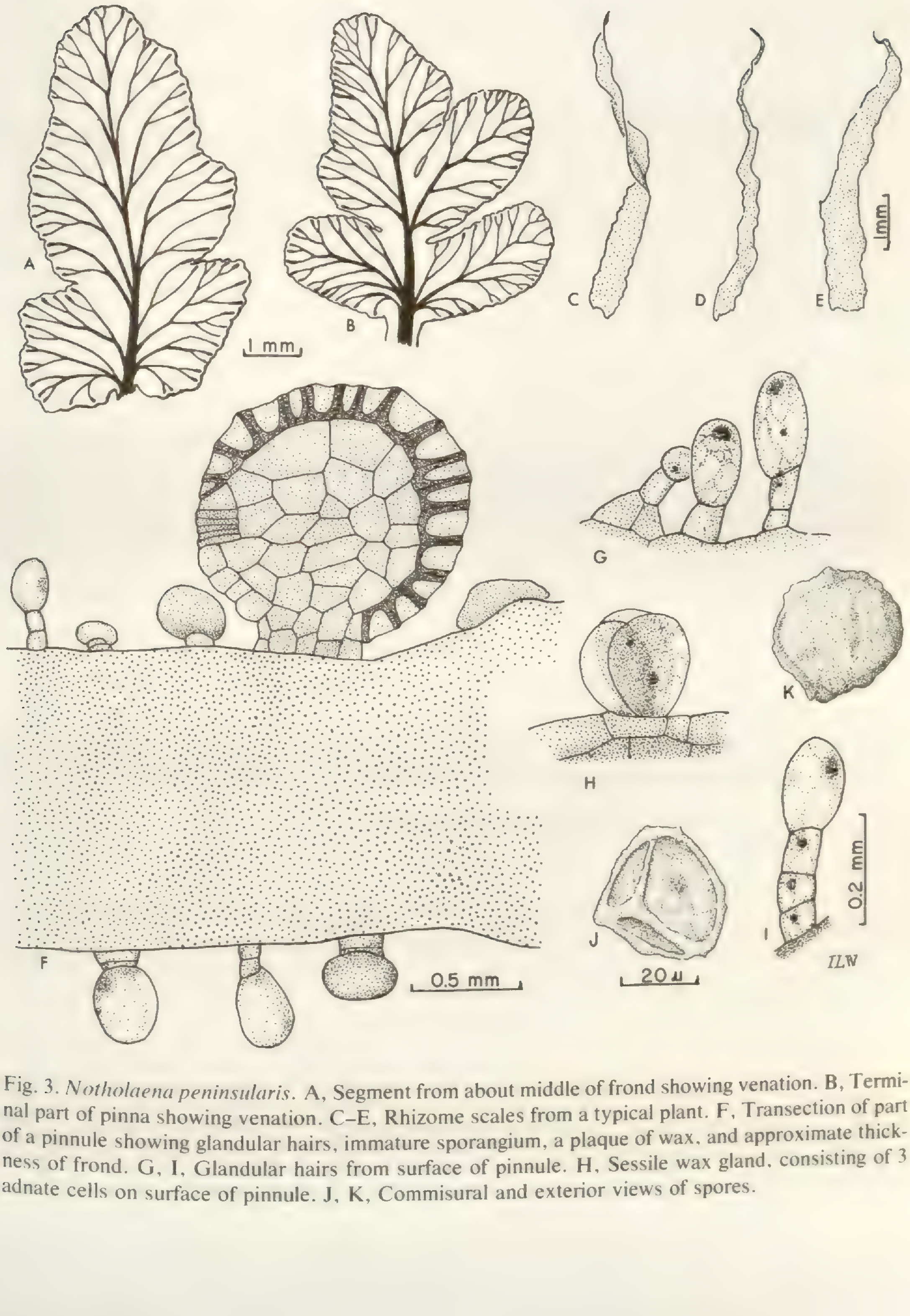


Fig. 3. *Notholaena peninsularis*. A, Segment from about middle of frond showing venation. B, Terminal part of pinna showing venation. C–E, Rhizome scales from a typical plant. F, Transection of part of a pinnule showing glandular hairs, immature sporangium, a plaque of wax, and approximate thickness of frond. G, I, Glandular hairs from surface of pinnule. H, Sessile wax gland, consisting of 3 adnate cells on surface of pinnule. J, K, Commisural and exterior views of spores.

Induction of Apogamy in Pellaea glabella var. occidentalis[1]

S. JANE RIGBY*

Apogamy—the formation of a sporophyte from the vegetative cells of a gametophyte—can be divided into two types, obligate and induced. Obligate apogamy is the normal means of reproduction in certain fern species; in other, normally sexually reproducing species apogamy can be induced in response to specific cultural conditions.

One condition necessary for the induction of apogamy is the prevention of fertilization. This can be achieved by witholding free water from the gametophytes (Lang, 1898; Manton, 1950; Steil, 1951). Whittier and Steeves (1960) found that sugar in the growth medium promoted the induction of apogamy in certain species of ferns; in a later study (1962) they noted that the optimum sugar concentration varied from one species to another. Other conditions which also affect the induction of apogamy are the presence of various growth substances (Whittier, 1966) and of ethylene (Elmore & Whittier, 1973) in the cultures, and the intensity and quality of the light to which the gametophytes are exposed (Whittier, 1964; Whittier & Pratt, 1971).

Apogamy provides a system for studying the development of sporophytic from gametophytic tissue with no change in chromosome number. In addition, when sporophytes resulting from induced apogamy can be raised to maturity, the pairing patterns of their chromosomes at meiosis may indicate the amount of homology among the chromosomes, and thus may provide some evidence as to the evolution of the species (Manton, 1950; Manton & Walker, 1954; Bouharmont, 1972; Vida, 1972).

Obligate apogamy occurs in several species of *Pellaea* (Tryon, 1957), but apogamy has not been experimentally induced in this genus. The object of the present study was to induce apogamy in a sexual variety of *Pellaea* in order to determine the conditions suitable for induction of apogamy in this taxon and also to obtain apogamous sporophytes to raise to maturity for chromosomal analysis.

MATERIALS AND METHODS

The *Pellaea glabella* complex consists of two obligately apogamous tetraploids—*P. glabella* Mett. ex Kuhn var. *glabella* and *P. glabella* var. *simplex* Butters—and two sexual diploids—a recently discovered diploid cytotype of var. *glabella* (Wagner et al., 1965) and *P. glabella* var. *occidentalis* (E. Nelson) Butters. This latter variety was used in the present study. Spores of *P. glabella* var. *occidentalis* collected at Spearfish Canyon, South Dakota, were germinated on soil; subsequent fertilization produced normal sporophytes. Spores collected from these plants were surface-sterilized in 10% "Javex" (equal to a 0.6% aqueous

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[1]Financial support for this study was provided through the Research Advisory Board, University of Guelph. The author wishes to thank Dr. D. M. Britton for his helpful comments.

solution of sodium hypochlorite) and sown on a modified (Whittier, 1968) Knudson's medium (pH 6, 0.6% agar). Gametophytes of *Pellaea glabella* do not develop antheridia when grown on this medium, and so accidental fertilization cannot take place. To determine the optimum sugar concentration for the induction of apogamy in *P. glabella*, sucrose was added to the basic medium at concentrations of 0, 1.25, 2.5, 3.75, 5.0 and 6.25% (referred to as 0S, 1.25S, 3.75S, 5S and 6.25S respectively). After three weeks, 150 prothalli from each of the six sucrose concentrations were transferred to petri plates of fresh medium, 25 prothalli to each plate. The prothalli were grown in a light intensity of approximately 400 ft-c, on a 12-hour photoperiod and were transferred to fresh medium at five to six week intervals.

Root tips for chromosome counts were treated in saturated aqueous PDB for four hours at room temperature, macerated in concentrated HC1:95% ethanol (1:1) for five minutes, and fixed for 18 hours in absolute ethanol:glacial acetic acid (3:1). Squashes were made using the propionic-iron-haematoxylin technique described by Lu (1967) except that, to prevent precipitation of the iron, the material was first placed briefly in a drop of solution A, blotted to remove the excess liquid and then flooded with solution B.

DEVELOPMENT OF THE PROTHALLI

Prothalli on media with low sugar concentrations (1.25S, 2.5S and 3.75S) initially developed faster than those on either media with high sugar concentrations (5S and 6.25S) or the medium without sugar. By the 33rd day, archegonia had appeared on 75 to 80% of the prothalli grown on the 1.25S, 2.5S and 3.75S media and on approximately 30% of the prothalli on the 5S and 6.25S media. None of the prothalli grown on the 0S medium had produced archegonia. No antheridia were observed on any of the prothalli. These observations concur with those made on diploid *P. glabella* var. *glabella* by Whittier (1968). By the 40th day, however, archegonia were present on 90% of the prothalli on each of the six different sucrose concentrations. Subsequently the prothalli on the 0S medium grew fastest, and their morphology resembled the normal condition as described by Pray (1968), whereas the prothalli developed more slowly and became more irregular as the sucrose concentration was increased. Twenty-five prothalli from each sucrose concentration were measured after 108 days, and their average lengths per concentration were compared by means of Duncan's Multiple Range Test. In all cases, the higher the sucrose concentration, the shorter the average length of the gametophytes. From fifteen possible comparisons of means, only one pair (0S vs. 1.25S) showed no significant difference at the 5% level.

Approximately 100 days after the spores were sown, the prothalli began to proliferate. Gametophytes on the 0S medium formed a thickened central cushion from which arose lobes that often resembled young, heart-shaped prothalli. Although some brownish patches appeared on these cushions, the prothalli generally remained green. Prothalli grown on media containing sucrose showed considerably more browning of the cushion, and their proliferations were often small and irregular. These effects were first seen and were most striking on the prothalli

Pellaea glabella var. *occidentalis*. Fig. 1. Apogamous leaf arising from thickened cushion of prothallus. Fig. 2. Prothallial cushion showing independent origin of apogamous leaves. Fig. 3. Apogamous leaves arising from prothallial cushion. Fig. 4. Same plant as in Fig. 3, showing roots at base of prothallial cushion.

grown on the media with the highest sucrose concentrations, but eventually, by the 150th day, all the sucrose-grown prothalli appeared as brownish lumps of charred-looking tissue, with irregular (often very small) green proliferations.

INITIATION AND DEVELOPMENT OF APOGAMOUS STRUCTURES

Approximately 150 days after the spores were first sown, one of the prothalli on the 0S medium produced a three-lobed leaf, distinctly sporophytic in character, with veins visible in the lobes. The prothallus and its apogamous leaf were transferred to soil, but died after two weeks. Examination of the dead plant showed no sign of roots.

While in the next four months only two more sporophytes appeared on the 0S medium, during the subsequent three months 24 more prothalli on the 0S medium produced apogamous leaves. The prothalli on the media containing sucrose were generally badly charred by this time; no apogamous leaves had appeared on them, and those which had not already died were discarded.

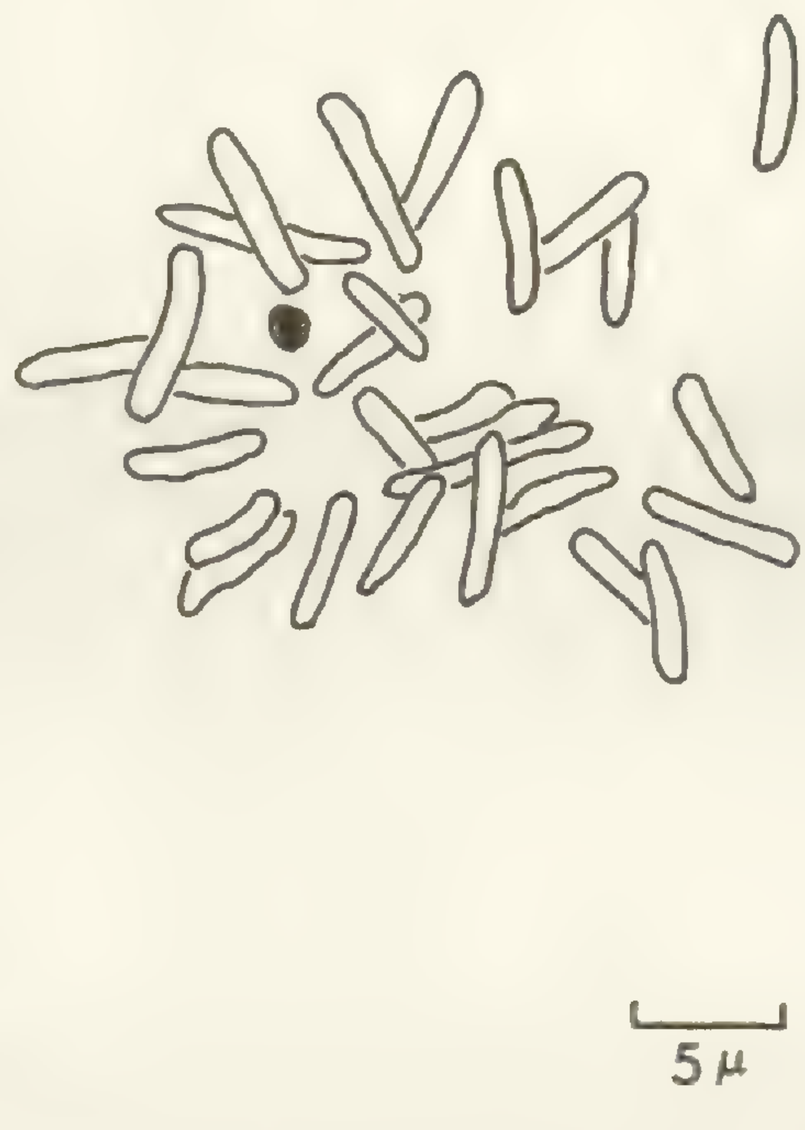
The first apogamous leaf to appear on a prothallus was generally simple but deeply lobed, in contrast to the rotund-cordate first leaves of sexually produced sporophytes of var. *occidentalis*. The first leaf arose from the thickened cushion of the prothallus (*Fig. 1*) and was followed by subsequent leaves arising independently from the same cushion (*Fig. 2*) to form a cluster of leaves (*Fig. 3*). Frequently these later leaves were not lobed and resembled the typical juvenile leaves of var. *occidentalis*. One or more of the leaves in a cluster might serve as a starting point for additional leaves and a stem (*Fig. 2*, lower right). A single prothallus could produce two or more thickened cushions, each giving rise to a cluster of apogamous leaves. The gametophytic tissue continued to grow and produce new lobes after the first apogamous leaves had been induced. Although roots sometimes developed around the base of the leaf cluster shortly after the first leaves appeared, more often root initiation was delayed for several weeks. In some prothalli no roots were produced and the apogamous response was limited to isolated leaves. In cases where roots did appear, they frequently twisted around the base of the prothallial cushion, rather than growing down into the medium (*Fig. 4*). Regardless of whether the apogamous sporophytes were left on the prothallus or excised and transferred to fresh medium, their rate of development was usually slow, although it varied from plant to plant so that stage of development could not be meaningfully correlated with age in days.

Approximately 100 days after it was first observed, one of the apogamous sporophytes with three or four roots was transferred to soil, where its development continued to be slow. After 90 days it had lost all eight leaves present at the time of transfer, and produced only three new ones. During this time, nine other apogamous sporophytes were transferred to soil, where they also developed slowly.

The apogamous origin of the sporophytes was confirmed by mitotic squashes of root tips from a plant which had produced ten roots (*Fig. 5*). These squashes show approximately 29 chromosomes, which is the haploid number for *P. glabella* var. *occidentalis* (Tryon & Britton, 1958).

DISCUSSION

While the present study shows that apogamy can be induced in *Pellaea glabella* var. *occidentalis* without adding sugar to the medium, at least five months were required for the first apogamous leaves to appear, and most of the apogamous shoots were not produced until nine months after the spores were sown. Although the presence of low concentrations of sucrose in the medium seem to produce an initial spurt of growth, subsequently the presence of sucrose appears to be detrimental to normal growth of the prothalli and produces a charring effect. Similar charring at high sucrose concentrations (6S, 7S and 8S) has been reported by Mehra and Sulklyan (1969) in gametophytes of *Ampelopteris prolifera*.



Pellaea glabella var. *occidentalis*. Fig. 5a. Mitotic metaphase from tip of apogamous root. Fig. 5b. Explanatory diagram for Fig. 5a, showing ca 28 chromosomes. The black body is probably nucleolar material.

The development of the apogamous sporophytes of *P. glabella* var. *occidentalis*, as reported above, can be compared with development of apogamous sporophytes in other genera in which apogamy has been induced.

Duncan (1941) induced apogamy in *Doodia caudata* and noted that the first leaf of the apogamous sporophyte was typically pinnately divided or lobed. The primary leaf of a sexually produced sporophyte of this species is usually simple and entire. Duncan found that apogamous sporophytes of *D. caudata* were delicate and difficult to keep alive, although a plant from one of his cultures was eventually raised to maturity (Manton, 1950). Manton notes that this plant developed slowly in comparison with a sexually produced sister plant.

In both *Dryopteris dilatata* and *D. filix-mas* (Manton & Walker, 1954) apogamous sporophytes began as a cluster of small leaves. Roots, if they appeared, usually developed later. In both of these species apogamously produced plants were smaller than sister plants resulting from fertilization.

Whittier (1962) observed that in *Pteridium aquilinum* induced apogamy sometimes resulted in isolated leaves, rather than entire plants, and that when roots did occur, they usually formed adventitiously, from the stem.

When apogamy was induced in *Ampelopteris prolifera* (Mehra & Sulklyan, 1969), some prothalli produced only roots, but when entire plants were formed, the first organ was typically a pinnately divided leaf, in contrast to the simple first leaves of sexually produced sporophytes. This leaf arose from a thickened cushion of the prothallus and was followed by a shoot apex and eventually by roots.

Bouharmont (1972) found that sporophytes resulting from induced apogamy in *Asplenium septentrionale* grew very slowly and took several months to produce roots.

These examples indicate similarities in the development pattern of sporophytes resulting from induced apogamy in several unrelated fern genera. Divided first leaves, slow development, and late root initiation appear to be part of this pattern, and are all displayed by *Pellaea glabella* var. *occidentalis*. This variety seems suitable for use in conjunction with the closely related obligate apomicts *P. glabella* var. *glabella* and *P. glabella* var. *simplex*, in providing meaningful comparisons between induced and obligate apogamy.

LITERATURE CITED

BOUHARMONT, J. 1972. Meiosis in apogamously produced diploid plants of Asplenium septentrionale. Brit. Fern Gaz. **10:** 237–240.

DUNCAN, R. E. 1941. Apogamy in Doodia caudata. Amer. J. Bot. **28:** 921–931.

ELMORE, H. W. and D. P. WHITTIER. 1973. The role of ethylene in the induction of apogamous buds in Pteridium gametophytes. Planta (Berl.) **111:** 85–90.

LANG, W. H. 1898. On apogamy and development of sporangia upon fern prothallia. Phil. Trans. Roy. Soc. London, B 190:187–238.

LU, B. C. 1967. The course of meiosis and centriole behavior during the ascus development of the ascomycete Gelasinospora calospora. Chromosoma **22:** 210–226.

MANTON, I. 1950. Problems of Cytology and Evolution in the Pteridophyta. University Press, Cambridge, England.

————, and S. WALKER. 1954. Induced apogamy in Dryopteris dilatata (Hoffm.) A. Gray and D. filix-mas (L.) Schott emend. and its significance for the interpretation of the two species. Ann. Bot., N.S. **18:** 377–383.

MEHRA, P. N. and D. S. SULKLYAN. 1969. In vitro studies on apogamy, apospory and controlled differentiation of rhizome segments of the fern, Ampelopteris prolifera (Retz.) Copel. Bot. J. Linn. Soc. **62:** 431–443.

PRAY, T. R. 1968. The gametophytes of Pellaea section Pellaea: dark-stiped series. Phytomorphology **18:** 113–143.

STEIL, W. N. 1951. Apogamy, apospory and parthenogenesis in the pteridophytes. II. Bot. Rev. **17:** 90–104.

TRYON, A. F. 1957. A revision of the fern genus Pellaea section Pellaea. Ann. Mo. Bot. Gard. **44:** 125–193.

————, and D. M. BRITTON. 1958. Cytotaxonomic studies on the fern genus Pellaea. Evolution **12:** 137–145.

VIDA, G. 1972. Cytotaxonomy and genome analysis of the European ferns. Symp. Biol. Hung. **12:** 51–60.

WAGNER, W. H. Jr., D. R. FARRAR, and K. L. CHEN. 1965. A new sexual form of Pellaea glabella from Missouri. Amer. Fern J. **55:** 171–178.

WHITTIER, D. P. 1962. The origin and development of apogamous structures in the gametophyte of Pteridium in sterile culture. Phytomorphology **12:** 10–20.

————————. 1964. The influence of cultural conditions on the induction of apogamy in Pteridium gametophytes. Amer. J. Bot. **51:** 730–736.

————————. 1966. The influence of growth substances on the induction of apogamy in Pteridium gametophytes. Amer. J. Bot. **53:** 882–886.

————————. 1968. Rate of gametophyte maturation in sexual and apogamous forms of Pellaea glabella. Amer. Fern. J. **58:** 12–19.

————————, and L. H. PRATT. 1971. The effect of light quality on the induction of apogamy in prothalli of Pteridium aquilinum. Planta (Berl.) **99:** 174–178.

————————, and T. A. STEEVES. 1960. The induction of apogamy in the bracken fern. Can. J. Bot. **38:** 925–930.

————————, and T. A. STEEVES. 1962. Further studies on induced apogamy in ferns. Can. J. Bot. **40:** 1525–1531.

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SHORTER NOTES

A NATURAL LYGODIUM HYBRID FOUND IN TRINIDAD.—According to Maxon's treatment of *Lygodium* in the "North American Flora," the only species of the genus known in Trinidad are *L. micans* Sturm and *L. venustum* Swartz. Both are widespread over the island. *Lygodium venustum* usually inhabits partly sunny banks and grassy, open spaces; *L. micans* typically is found in the forest. The two often grow in close proximity on the forest edges. Leaves

Fig. 1. Pinnae of *Lygodium micans*. Fig. 2. Pinnae of *Lygodium micans* × *venustum*. Fig. 3. Pinnae of *Lygodium venustum*.

looking like a hybrid of the two were collected near Guayaguayare, in southeastern Trinidad, on May 8, 1971 (*Fay 635*, TRIN, US). As the pinnae in *Fig. 2* show, they are intermediate between those of the two parents. The plant was not fertile, although a fertile *L. micans* specimen was found in the same area on the same day. Spore production usually occurs about November, towards the end of the rainy season. I am indebted to Texaco Trinidad Inc. for their hospitality and for permission to explore and collect ferns on their lands.—*Alice D. A. Fay, Department of Chemistry, Furman University, Greenville, SC 29613.*

ANTS AND POLYPODIUM POLYPODIOIDES.—In the Neotropics myrmecophily in ferns has been thought to be restricted to a single genus of the Polypodiaceae, *Solanopteris,* in which the relationship of the ants and the fern is not yet entirely clear (see Wagner, W. H., Jr. Amer. Fern J. **72:** 42. 1972). Some time ago I found a population of *Polypodium polypodioides* (L.) Watt, a widely distributed epiphyte, growing on a dried trunk of the leguminous tree *Erythrina costaricensis* Micheli at Cóncavas, near Paraíso, Prov. Cartago, at an altitude of 1200 m. A specimen of the fern (*Gómez s. n.*) has been deposited in the University

of Michigan Herbarium. At the base and inside the tree trunk was a large nest of a small, black ant of the genus *Pheidole*. The fern rhizome showed spherical swellings densely clothed with scales and with an opening at the top. The ants were seen crawling in and out of these tuber-like structures, which I interpret as galls caused either by the ants through some hormonal mechanism on the growing rhizome or by insect larvae that left the enclosures, which were then visited by the ants. Dissections of a number of the galls showed considerable and recent damage to the parenchymatous tissues. The purpose of the visiting ants, as in the *Solanopteris*, is obscure.—*Luis Diego Gómez P., Herbario Nacional de Costa Rica, Apartado 749, San José, Costa Rica.*

NOTES ON SOME OPHIOGLOSSACEAE IN MISSISSIPPI.—The most recent list of ferns of Mississippi (Jones, Pullen & Watson, Sida 3: 359–364. 1969) includes Bulbous Adder's-tongue *(Ophioglossum crotalophoroides)* only from Lafayette County. Least Adder's-tongue *(Ophioglossum nudicaule* var. *tenerum)* and Prostrate Grape Fern *(Botrychium lunarioides)* have not been reported from Mississippi. The authors collected all three ferns in Mississippi during February, 1972.

We found *Ophioglossum crotalophoroides* to be common in sandy, grassy areas such as cemeteries and roadsides. We have specimens from the following 29 counties: Amite, Choctaw, Clark, Copiah, Covington, Forest, Franklin, George, Greene, Hancock, Harrison, Hinds, Jackson, Jones, Lamar, Lauderdale, Lincoln, Marion, Newton, Oktibbeha, Pearl River, Perry, Simpson, Stone, Walthall, Wayne, Wilkerson, and Winston.

Ophioglossum nudicaule, although not as abundant as Bulbous Adder's-tongue, is relatively common with sundews *(Drosera brevifolia)* and *Lepuropetalon spathulatum* (a rare, ephemeral annual often placed in the Saxifragaceae) in seepage areas in sandy cemeteries. It is also found in very dry, sandy areas in cemeteries. We have specimens from 14 counties: Amite, Clark, Covington, Forest, George, Greene, Harrison, Jones, Lauderdale, Lincoln, Marion, Perry, Simpson, and Wayne.

Botrychium lunarioides has a widely disjunct distribution on the Coastal Plain (Wherry, Southern Fern Guide, 1964). The authors first collected it in Mississippi in McClain Cemetery in Greene County. The site is very dry and sandy; ten specimens were seen along with several plants of *Ophioglossum nudicaule* and *O. crotalophoroides*. Rogers later collected it in Clark, Jones, Lauderdale, and Wayne Counties. The site in Jones County is a dry cemetery. Approximately 100 plants were growing in full sunlight.

All three ferns are hard to see and are best seen before other vegetation grows tall enough to over-top them. All three are probably more common than collections indicate.

Specimens are on deposit in the herbaria of Northeast Louisiana University and University of Southern Mississippi. When available, duplicate specimens were distributed to various other herbaria.—*R. Dale Thomas, Dept. of Biology, Northeast Louisiana University, Monroe, LA 71201 and Ken E. Rogers, Dept. of Biology, University of Southern Mississippi, Hattiesburg, MI 39401.*

REVIEWS

"A REVISION OF THE FERN GENUS NEPHELEA," by Gerald J. Gastony. Contr. Gray Herb. 203: 81–148. 1973.—The past two decades have witnessed the publication of several important additions to the literature on tree ferns, a group often confused or sadly neglected in the past. Behind the leadership of R. E. Holttum in England and R. M. Tryon, Jr. in the United States, there have been renewed efforts toward untangling problems in the classification and phylogeny of these fascinating plants. A recent example is Gerald Gastony's excellent revision of *Nephelea*.

Nephelea was first described in 1970 by Tryon in his classification of the Cyatheaceae. It is a neotropical genus whose species have appeared previously in such genera as *Cyathea, Alsophila, Hemitelia,* and *Lophosoria*, and is considered by Gastony to be a major evolutionary group of tree ferns. Of the 59 taxa formerly included in *Nephelea,* eighteen species are recognized in this revision. Nine varieties are proposed and one new species is described. Many species have been reduced to synonymy, either because they were misunderstood due to the fragmentary nature of early collections, or because some morphological extremes had been recognized as distinct species. The author has utilized a number of characters to indicate the affinity of *Nephelea* with *Alsophila* and to delineate the phyletic position of both within the family. Most important of these features are petiole scale structure, spore morphology, aphlebioid basal pinnae, and spore number per sporangium (16 in *Nephelea* and *Alsophila* versus 64 in the other genera of Cyatheaceae). Considerable attention is devoted to clarifying problems in morphology and anatomy; this section is greatly enhanced by excellent drawings and photographs. The key to species is well designed and easy to use, in spite of the necessity of employing a number of minute characters. Species descriptions are complete and painstakingly drawn.

It should be noted that the reprints of this revision contain a list of species and their varieties, an index to names, and an index to exsiccatae (according to species numbers) which are all lacking in the original publication. This information, privately appended to the reprints, adds substantially to the value of the work.

During the course of research approximately 2300 specimens were studied, including the author's own collections from Mexico, Costa Rica, Jamaica, and the Dominican Republic. Moreover, types of nearly all described taxa, whether accepted or in synonymy, were examined. Gastony's first major botanical contribution is a highly authoritative one!—*R. G. Stolze, Field Museum of Natural History, Chicago, IL 60605.*

"INDEX FILICUM AND SUPPLEMENTS I–III," by Carl Christensen, ca 1219 pp. 1905–1934, reprint 1973. Ca $105.00.—Pteridologists are fortunate in having a world-wide index to the species of ferns. Carl Christensen published the first volume of his "Index Filicum" in Copenhagen during the years 1905–1906. It included the names of ferns published from 1753 to the end of 1905. At the beginning of the "Index" is a list of genera, subgenera, and sections, with synonymy, in a taxonomic arrangement as Christensen saw them. (A revised list appears at the beginning of the third supplement.) The "Index" attempted to assess the taxonomic validity of the species as Christensen understood them or accepted them from monographs prepared by other workers. The species that Christensen thought were synonyms are referred to the species he accepted, but the synonymies given under the accepted species are not always complete. Recently F. A. Stafleu (Taxon **22:** 465–466. 1973) commented on the taxonomic background of the "Index Filicum" and made some interesting observations on Christensen's life and work. Those few species that Christensen could not place are listed (in italics) as dubious. Some *nomina nuda* are also included. Considering that the "Index" was published early in Christensen's career, his judgements have proved to be remarkably sound (although, of course, today's generic concepts differ somewhat from those of 70 years ago).

Christensen published supplements in the same taxonomic style in 1913 (for 1906–1912), in 1917 (for 1913–1916), and in 1934 (for 1917–1933). The first two of these divided the names newly published from those that were corrections to entries in the previously published parts. In the third supplement, the entries to be corrected were combined with the new entries. Lists of addenda and corrigenda are printed on pages 660–670 of the original "Index" and on pages 196–200 of the third supplement. These should not be overlooked in searching for names in the "Index" and its supplements.

At least parts of the "Index" have been out of print for some time, and now Otto Koeltz Antiquariat, Postfach 129, 624 Königstein-Taunus, Federal Republic of Germany, has reprinted the original "Index Filicum" in one volume and Supplements I through III in another. The 1905–1906 volume (ISBN 3-87429-048-4) sells for DM 265, and the three supplements (ISBN 3-87429-049-2) for DM 170. The reprints are reduced in page height by about 7.5% from the original volumes, but this in no way interferes with the legibility or usability of these clearly printed and strongly bound books. The original indices were printed at a time when paper chemistry had not solved fully the problem of deterioration, and so hard users and libraries will be gratified that their reprint volumes will last longer than the original ones.—D. B. L.

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ERRATA

Page 9, line 7. For "Moore" read "(Hook.) Moore."
Page 53, line 6. For "*Thelypteris mortoniana*" read "*Thelypteris mortonii.*"
Page 60, entry 266. The correct title is "William Roxburgh's Fern Types."
Page 60. Add: "267. A revision of the Argentine species of Solanum. Kurtziana (in press)."
Page 84, line 4. For "*strigosa*" read "*strigosum.*"
Page 101, legend line 2. For "*dudley*" read "*dudleyi.*"
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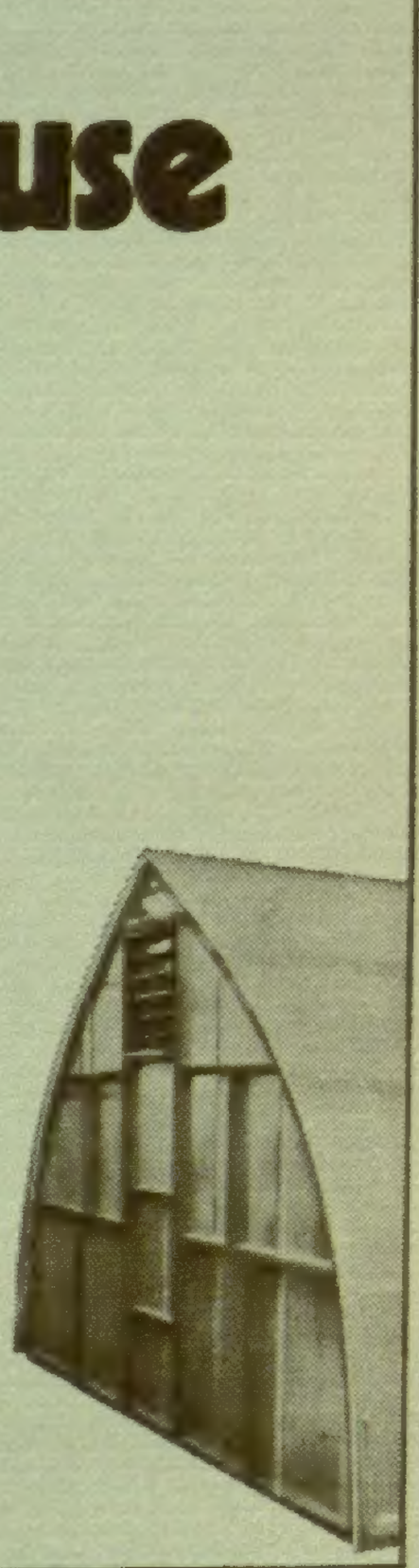

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